HIGHWAY ENGINEERS' REFERENCE BOOK

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FOR COUNTY AND MUNICIPAL ENGINEERS, CIVIL ENGINEERS AND CONTRACTORS

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LONDON

GEORGE NEWNES LIMITED

TOWER HOUSE, SOUTHAMPTON STREET, STRAND, W.C.2

First Published 1947

MADE AND PRINTED IN GREAT BRITAIN
BY JARROLD & SONS LTD. NORWICH

FOREWORD

The Highway Engineers' Reference Book has been prepared with the object of presenting, in a form convenient for reference, reliable information required by County and Municipal Engineers and Surveyors, Civil Engineers and Contractors, responsible for the planning, construction, administration and maintenance of the highways of this country.

The subject of Highway Engineering is of vital importance at all times, but is particularly so after seven years of war, during which it was only possible to maintain the existing roads in as good condition as could be achieved with the minimum expenditure of labour and material.

The Government policy for the future development of the highway system envisages a programme covering ten years of work; the experience gained during the war in dealing with problems of military traffic of very heavy character, both at home and abroad, should prove of immense value in approaching the problems of civilian use of the roads and alleviating the congestion of traffic in built-up areas.

One aspect of the problem, viz., the training of the road user in the intelligent use of the roads of this country, with a maximum degree of safety for all, has already been tackled in some measure by the issue to every household of a copy of the Highway Code, but all concerned with the design, construction and equipment of roads must direct their skill and experience towards solving the urgent problem of Road Safety.

In this book the various aspects of Highway Engineering are grouped under eight main headings:

Preliminary Surveys
Soil Stabilization
Road Lay-out
Lighting of Streets and Roads
Road-making Materials
Modern Road-making Methods
Equipment for Road Construction
Maintenance

In an endeavour to provide reliable and up-to-date information on all these aspects, the Editor has enlisted the help of several of the leading municipal and county engineers, and of experts in specialized types of construction and street lighting.

The assistance of the manufacturers of all types of road-making material and equipment has also been welcomed, and the information supplied by them has been included at the end of each appropriate section of the book.

Special acknowledgments are due to The Asphalt Roads Association, The British Granite and Whinstone Federation, The Federation of Coated Macadam Industries, The Rubber Growers' Association and The Timber Development Association for their help in the preparation of articles dealing with specialized subjects, to The British Granite and Whinstone Federation and The Limestone Federation for their assistance in compiling the colour plate showing the location of roadstone quarries in Great Britain, and to The British Road Tar Association, for their co-operation in the obtaining of reliable information on technical aspects of the materials and types of construction in which they specialize.

Thanks are also due to The Bedfordshire Historical Society for their assistance in obtaining illustrations of ancient toll-gates, and to Messrs.

Alexander Duckham and Company, Limited, for their help in compiling notes on the lubrication of mechanical plant.

It is believed that by placing before county and municipal engineers, civil engineers and contractors the results of recent research and development in materials, plant and constructional methods, the Highway Engineers' Reference Book will fulfil a real need at the present time.

E. MOLLOY,

GENERAL EDITOR

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Received his training in Engineering at the Sheffield University and with Messrs. Cammell Laird & Co. Ltd., Sheffield. During the 1914–1918 War he was a Transport Workshop Officer attached to the Indian Army. In 1921 he became Chief Engineer and Assistant Cleansing Superintendent to the City of Sheffield and in 1926 was appointed Director of Public Cleansing to the County Borough of Blackpool. Since 1933 he has held the position of Director of Public Cleansing to the City of Westminster. He is the Hon. General Secretary of the Institute of Public Cleansing, an office he has held for the past fifteen years.

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Was trained in preparation for the Royal Navy in which he served until 1930, specializing in engineering duties. After leaving the Service he took the electrical training course at Faraday House, including practical testing and design work with Messrs. Laurence, Scott and Electromotors, Ltd., at Norwich, and from which he emerged as Gold Medallist. In 1932 he joined the engineering staff of the Lighting Service Bureau and has remained there until the present time. As Technical Editor of this organization he is responsible for the preparation of all its textbooks and other publications, and is the author of "Fluorescent Lighting" (*Geo. Newnes Ltd.*).

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Has served as County Surveyor of Gloucestershire for the last twelve years. He was educated at the City of London School and London University and during his early career held appointments in Norfolk, Shropshire and Surrey. From 1929–34 he was Chief Assistant Engineer to the West Sussex County Council and in 1932 was appointed Deputy County Surveyor of Gloucestershire, becoming County Surveyor in 1934. He is a member of various Research Committees including those dealing with Soil Stabilization and Concrete Roads.

SPENCE GEDDES, E.S.Dipl.

Was educated at the Elgin Academy and at the Royal Technical College, Glasgow, where he was awarded a Diploma in Engineering Science in 1921. He began his career by working with his father, George Geddes, who was a quarry master and contractor, and with whom he gained experience in quarrying on a large scale, in the production of aggregates and in the construction of roads. From 1923–38 he was actively engaged in civil engineering with The Consolidated Construction Co., London, Messrs. William Tawse, Contractors of Aberdeen, and Messrs. C. J. Wills of London, Contractors to the London County Council. During this period he was engaged on contracts covering water mains, jetties, main sewers, roads and bridges. For the past eight years he has been associated with Messrs. Bridgewater Bros., Public Works Contractors, in estimating and administering the construction of aerodromes, runways, roads, water mains and sewers.

S. A. HOLLOWAY, Assoc. M. Inst. H.E.

Was educated at St. John's School, Ealing, and the Ealing Technical Institute. He served in the 1914–18 War with the 8th Batt. of the Middlesex Regiment. He supervised road and sewer contracts, and private estate development under local authorities where concrete foundations and concrete finished roads have been the general method of construction. Has written a series of articles on the Construction of Concrete Carriageways from the preparation of the sub-base to the finished surface.

A. E. LAWRENCE, B.Sc., A.R.I.C., M.Inst.Pet.

Educated at University College, Southampton and London University, where he graduated in 1935. Since that date he has held the appointment

of Senior Roads and Soils Chemist to British Bitumen Emulsions Ltd. In addition to laboratory work, he has had considerable experience of field work involving stabilization with emulsified bitumen. He is a member of the Soil Testing Panel of the British Standards Institution and of the Soil Stabilization Panel of the Institute of Petroleum.

E. L. LEEMING, M.Sc.(Tech), M.I.C.E.

Engineer and Surveyor to the Urmston (Lancs.) Urban District Council. He formerly held a similar position with the Barton-upon-Irwell Rural District Council, and prior to that saw service with the Manchester Corporation. Is the author of "Road Engineering" (*Constable & Co.*) and of many technical papers on the same subject. He was British Delegate to the International Roads Congress at Washington in 1930, Munich in 1934, and at the Hague in 1938. Has travelled widely in Europe and America. He is the author of the plan for Satellite Towns in Southern Rhodesia, and has broadcast on several occasions on Town Planning subjects both in this country and in America.

A. J. LYDDON, C.B.E., M.I.C.E., Hon.Mem.Inst. M. & Cy.E.

Was Chief Engineer and Deputy Chief Engineer respectively of the Roads Department of the Ministry of Transport, for a period of ten years prior to 1945. Subsequent to his retirement from the Civil Service he accepted the appointment of Director of the Federation of Coated Macadam Industries, a body representative of a large section of the industry concerned with the manufacture and laying of road surfacing materials. As Divisional Road Engineer in the Northern Division of the Ministry of Transport, from 1921–3 and from 1928–35, his diocese extended over the counties of Cumberland, Durham, Lancashire, Northumberland, Westmorland and the East, North and West Ridings of Yorkshire. From 1923–8, he was specially seconded by the late Sir Henry Maybury to take charge of the construction of London Arterial Roads, which involved a total expenditure of £15,000,000. Has been County Surveyor of the North Riding of Yorkshire and Deputy County Surveyor of Essex respectively. During the 1914–18 War his services were lent by the Essex County Council to the Road Board for the construction and maintenance of roads in service Establishments in this country. In connection with the construction of runways during 1940–4 he perfected a method of mixing wet sand and hot bitumen which made it possible to construct runways more rapidly and economically than by any other method to the extent of over 12,000,000 square yards. He served in a professional capacity with a number of Local Authorities from 1903–11.

J. N. McFEETERS, M.Sc., M.I.C.E., M.I.Struct.E.

Was educated at Bangor (Co. Down) Grammar School, and Queen's University, Belfast, where he graduated as B.Sc. in Civil Engineering in 1925 and M.Sc. in 1931. During 1936 he was Assistant Engineer to Messrs. Braithwaite & Co., Engineers, Ltd. and in 1928 served as Assistant Engineer in the Works Department of the Government of Northern Ireland, working on design and construction of large river and harbour works. He held various Government appointments in an executive capacity, specializing in road, bridge and airfield construction. During the late war he was Assistant Director in charge of Factory and Airfield Design and Construction at the Ministry of Aircraft Production. He is now a member of the Department of the Chief Scientific Adviser, Ministry of Works, in charge of the Soil Mechanics Section, which is concerned with Site Investigation for Heavy Foundations, Earth Works, Runways, etc. Is the author of "Concrete Runways" Airport Paper No. 2. (Inst. of Civil Engineers—Feb. 1946).

L. T. MINCHIN, B.Sc., M.Inst.Gas E., F.I.E.S.

Spent the first 19 years of his career with the Gas Light & Coke Company's Laboratories at Watson House, London. He organized the first Photometric Laboratory there and made the first systematic study of the light distribution from gas lighting units. He is the author of a paper on "Principles of Gas Lamp Design", published in 1934. In 1940 he read a paper on "Some Physical Problems Associated with Gas Lighting" to the Illuminating Engineers Society, during which he demonstrated the luminescence of boron nitride under flame excitation, probably for the first time in this country. During the late war he was engaged in research work for the Ministry of Aircraft Production on mixing and combustion in gas turbines. He is a member of the B.S.I. Committee on Street Lighting and of the Drafting sub-Committee which is preparing the Specification, and is also a member of the Joint Lighting Committee of the Institution of Gas Engineers and the Society of British Gas Industries. In June 1946 he resigned from his position with the Gas Light & Coke Co. in order to practice as a consultant.

W. P. ROBINSON, C.B.E., B.Sc., M.I.C.E.

Graduated at Yorkshire College, Victoria University. During his early career he served as Engineering Assistant with the Lancashire & Yorkshire Railway Company and as Chief Engineering Assistant to the County Surveyor of Durham. In 1912 he was appointed County Surveyor to the Eastern Division of Devonshire. During the 1914–18 War he was in command of the 312th Road Construction Company Royal Engineers, and later as an Assistant Corps Roads Officer in France and Belgium. In 1920 he was appointed County Surveyor to the Surrey County Council. Was President of the County Surveyors' Society (1929–30). He has served on the Road Research Board and is a member of the Technical Advisory Committee on the Layout of Roads to the Ministry of Transport. Is a member of Several B.S.I. Committees including the Roads and Road Engineering Industry Committee.

R. G. H. SALMON

Educated at Sherborne School, and apprenticed to Metropolitan Vickers Ltd., Manchester. Spent ten years in Canada and the U.S.A. in work closely connected with concrete road construction. Director of Spicers (Asbestos) Co., manufacturing materials for concrete roads and for the building industry, in Vancouver, B.C. Since 1934 has been a director of Expandite Ltd.

F. S. STRONGMAN, A.M.Inst. M. & Cy.E.

Was articled to the late Lt.-Col. E. B. Martin, D.S.O., M.I.C.E. His first appointment was in the office of the City Engineer, Salford, where he was engaged on road, bridge and sewerage works. He was later appointed Assistant to the City Engineer, Coventry and supervised work on the construction of roads and sewers on new housing estates, and the maintenance of plant, roads and sewers, all carried out by direct labour. In 1938 he was appointed Senior Assistant to the Borough Engineer, Dagenham. For the past four years he has served in various Government Departments, firstly on the layout, construction and maintenance of Ministry of Aircraft Production Airfields and Factories in all parts of the country, and latterly in the Soil Mechanics section of the Department of the Chief Scientific Adviser to the Ministry of Works.

LEONARD J. VEIT, O.B.E., F.S.I.

Began his career as a pupil and assistant in the office of the Surveyor to the Berners Estate, London, W.1. He subsequently entered the office of the Borough Engineer of Ipswich and later held appointments at Bury St. Edmunds, Wolverhampton, Barrow-in-Furness and Goole. In 1902 he entered the service of the Westminster City Council as Divisional Surveyor, later becoming Assistant City Engineer. In 1922 was appointed City Engineer to the Westminster City Council, which appointment he held until his retirement in 1935. During his term of office great developments in traffic arrangements took place, following the change over from horse to motor transport, and the extension of the Tube railways.

HIGHWAY ENGINEERS' REFERENCE BOOK

THE DEVELOPMENT OF THE HIGHWAY IN GREAT BRITAIN

By EDWARD STEAD, M.C., A.M.I.C.E., F.S.I., M.T.P.I. (Advisory Editor)

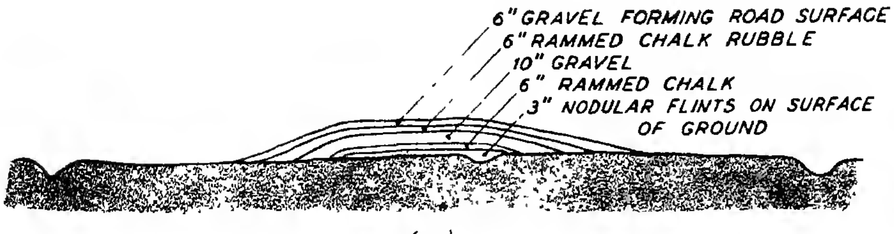
ALTHOUGH it is realized that it is not customary in books of a technical character for much space to be given to anything in the nature of an introduction, it is felt that in the present instance an exception might profitably be made by a departure from the accepted practice.

In view of the extreme and ever-growing importance of the subject, and in particular the comprehensive scheme of road development foreshadowed by new legislation, it is proposed before proceeding to the purely technical sections of the work to review on very broad lines the historical background which led to the highway system as we know it today. The article describes the gradual and continuous—though unfortunately intermittent—development of road construction in this country from the far-off days of the primitive and largely ineffective methods of the early pioneers, their trials and difficulties, to the costly, highly skilled and technical methods in operation at the present time, and closes with a reference to the Government's policy for the immediate future.

THE ROMAN ROADS

Leaving out of account the trackways of ancient Britain, the earliest systematically-designed roads in Britain were those of the Romans who invaded and occupied the land from 55 B.C., when our ancestors were favoured by the first visit of Julius Cæsar, until A.D. 410 when the Roman Troops were withdrawn, a total period of 465 years, after

FIG. 1.—THE OLD TOLL-GATE, FORMERLY AT WATLING STREET, DUNSTABLE.
(*Index Publishers (Dunstable), Ltd.*)



(a)

(b)

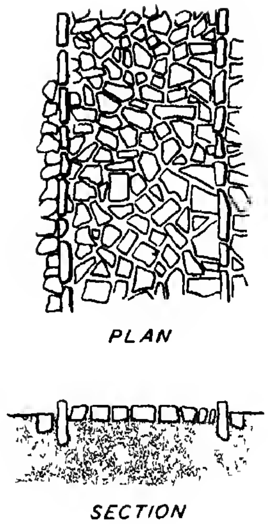


FIG. 2.—SECTIONS OF ROMAN ROAD
(a) Bokerley Dyke (between Old Sarum and Badbury)
(b) Road at Blackpool Bridge (Forest of Dean)

which Britain was never regarrisoned. The Roman system was very largely dictated by military necessities, commercial activities and social amenities occupying a secondary place, or perhaps it would be more correct to say that the road needs of the two latter considerations were grafted upon the military road system.

It is probable that many of the Roman roads were in actual use in the first century A.D. and that they were constructed by the soldiery. Little is known as to the actual administration or maintenance of these roads but it is a fair assumption that they were under the care of the several military commanders. The Roman roads were distinguished for their straight lines and to a great extent were built regardless of the natural features of the country, they were generally constructed with a paved stone foundation and as they were not required for much wheeled traffic but chiefly for marching troops they were no doubt admirable roads for the needs of the times.

From the time of the Roman evacuation in the fifth century very little indeed is known of the road system in use until the twelfth or thirteenth century. Doubtless the Roman system continued to be used in the intervening period, but of course in much lessened intensity, and it may be assumed that practically no attention was given to maintenance, and no new construction was undertaken. It appears to be established that from the disappearance of the Romans until the eighteenth century there was no attempt to construct or provide a solid or hard surface for the roads and that during that long period the idea of maintaining the roads never got beyond clearing away impediments and very occasionally filling up large holes or ruts. Very often if one road became impassable the traffic made another by taking passage over the adjoining land.

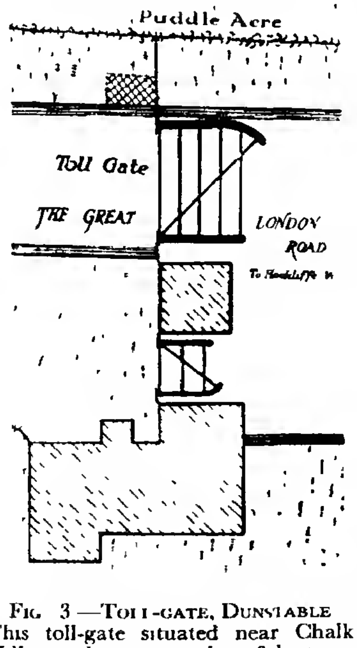


FIG. 3.—TOLL-GATE, DUNSTABLE
This toll-gate situated near Chalk Hill, was shown on a plan of the town dated 1762, in the custody of the "County Records Committee".
(Reproduced from an enlarged drawing by C. E. Freeman)

THE STATUTE OF WINCHESTER

In the twelfth century the duty of keeping open the highway was laid upon the Lord of the Manor, who no doubt generally passed the liability to his tenants without pay or reward! The Statute of Winchester in 1285—the first statute to deal with roads—ordered *that highways leading from one market town to another shall be enlarged where no bushes, woods or dykes be, so that there be neither dyke nor bush whereby a man may lurk to do hurt within 200 feet of the one side and 200 feet of the other side of the way.* The necessity for the passing of the above enactment indicates the existence of perils for the wayfarer other than those due to the state of the road.

There is no doubt that from about that time until the middle of the fifteenth century a good deal of travelling was occasioned by the provincial fairs and the innumerable local markets; wheeled traffic was practically non-existent and all travelling was pedestrian or on horseback, pack horses being used for the transport of goods. The end of the fifteenth century witnessed the start of a heavy decline in the

FIG 4 —RURAL MAIN ROAD, DEVON, 1913

(Devon County Council)

use of the roads, possibly due to the continual wars, the despoliation of the religious houses during the reign of Henry VIII and the lessening in the numbers and frequency of the great markets and fairs It had been the custom of the monasteries to undertake a large share of the maintenance of the roads and consequently, after the loss of their properties and revenues repair work became less and less until the roads were reduced to a really deplorable state, with the result that Parliament was compelled to take action towards amending matters

THE STATUTE OF WILLIAM AND MARY

In 1555 the Statute of Philip and Mary was passed and for nearly 300 years this statute formed the basis of organization for road maintenance It placed the obligation for the repair of highways upon the Parish and is the first Act creating the office of Surveyor of Highways The Act provided for a compulsory supply of labour in that every parishioner holding certain land or property was obliged without pay to labour for six consecutive days in the year, or to provide certain team labour for the road works. To the Parliament of 1555 must be accorded the credit of "something attempted something done", but the results were by no means in accord with expectations It is easy to imagine the serious difficulties of the unpaid Surveyor of Highways in his attempts —generally futile—to get any work out of his unwilling and enforced labourers, even when he had arranged their sequence of six consecutive days He had to act as a kind of police constable on traffic to see that it comported itself in accordance with the law, he was liable to heavy fines if he failed in or neglected any of his unpaid duties and he was the target for the abuse of all and sundry—the road users, the road labourers and the Justices of the Peace whom he had to annoy by reporting defaulters

At this time the country roads were little more than rude tracks across heaths and commons and any attempt to pass along them in winter was much the same as travelling in a ditch The only attempt at mending them was by throwing large stones into the larger holes and allowing the traffic to do the rest By travel and weather the earth was gradually worn into deep depressions, many of which still remain today in an improved form as highways.

THE COMPULSORY HIGHWAY RATE

The attempt to keep the roads in repair by compulsory labour was a failure and in 1654 the compulsory Highway Rate was instituted by the Government of the Commonwealth, such rate being limited to one shilling in the pound. With the accession of Charles II in 1660 the legislation of the Commonwealth became invalid and the Highway Rate no longer operated, but as it had apparently been recognized that the roads could not be mended without money, other attempts, all of a temporary nature, were made to levy rates for the purpose. Rates were no more popular in those days than they are to-day and in general all attempts to levy highway rates failed, and up to the end of the eighteenth century Statute Labour appears to have been the main resource.

COMMON LAW RIGHT OF INDICTMENT

Attempts to introduce a regular Highway Rate having failed use was made of the Common Law right of indictment at Quarter Sessions or Assizes in order to obtain some measure of repair to the roads. The method about to be described was in general use throughout the country and in spite of being most cumbersome it did effect some amelioration of road conditions. Anyone could indict the parishioners of the parish in which a founderous road lay and at the trial, if the parish could not show that the obligation to repair rested by tenure or by immemorial custom on some particular landowner, Quarter Sessions imposed a substantial fine on the inhabitants generally, but usually deferred levy to allow time for the repairs to be done. If the work was done the fine was eventually excused, but if not the Sheriff would be directed to levy it by distress upon any of the occupiers of the parish and to pay it—usually to the Surveyor—for the mending of the highway.

FIG. 5.—LYNMOUTH HILL, DEVON, 1914
(Montague Cooper, Lynton)

INCREASE IN ROAD TRAFFIC

During the latter part of the sixteenth century a slow and almost imperceptible increase in road traffic set in year by year, and the growth of traffic continued at a more rapid rate through the seventeenth and eighteenth centuries. There was more foreign trade, more trade with the very large towns, people ceased to rely upon the family industry for the production of domestic requisites and looked instead to the supply of those needs by distribution from some centre of manufacture. Thus the "local" use of the roads steadily diminished and the outside or "foreign" use increased, but the whole traffic was foot, horse or cattle, and it is worthy of note that almost down to the middle of the nineteenth century wheeled traffic in the country areas was most rare. We are told, for instance, that the roads of Somerset in 1695 were full of carriers of coal, strings of horses passing and returning laden with coals, Bristol and Bath being great centres for this coal traffic. The first vehicles put upon the roads were heavy and clumsy springless wagons requiring teams of six or eight horses to drag them through the vile roads at even so slow a pace as three or four miles an hour, and often covering not more than fifteen miles on a long summer's day.

STAGE COACHES

The first stage coaches began to run about 1750, the journey from Bath to London occupying about three days, and such swift travelling was

considered to be not only wonderful but very dangerous In the next fifty years stage coaches appeared on most of the main lines of communication but no satisfactory arrangement was made for the improvement or repair of the roads, the parish still having the duty cast upon it of maintaining roads for others to use, an imposition no doubt greatly and justly resented The State appeared to be quite unable to devise a proper road administration system, though many attempts were made to fit the traffic to the road instead of the road to the traffic—a rather Gilbertian procedure

Fig 6—Improved Rural Main Road, Somerset, 1925

THE TURNPIKE SYSTEM

At the beginning of the eighteenth century the roads were in such an abominable state and the traffic was increasing to such an extent that the Turnpike system was instituted Turnpike Trusts were established by separate Acts of Parliament and from 1706 onwards some hundreds of such Acts were passed. The principle underlying the establishment of Turnpike Trusts was that the user of the road contributed towards the cost of its upkeep and improvement Toll-houses and turnpike gates were erected on the roads and all who passed had to pay a toll There were many defects in the system and in its application, and severe abuse of the Trustees powers occurred repeatedly, nevertheless many very good improvements were carried out As the number of Turnpike Trusts increased so the cost of travelling rose and the increased road taxation aroused much hostility and resistance culminating in actual violence Serious riots broke out, toll-houses were pulled down and gates demolished, and the services of the military were frequently required to quell the disturbances Two great defects in the administration of Turnpike Trusts were the lack of ability of the Trustees and the failure to secure an adequate measure of technical skill in the Surveyors, which failure was responsible for the waste of thousands of pounds The greatest defect, however, was in the almost complete lack of financial control

FIG. 7 — IMPROVED ARTERIAL ROAD SOMERSET, 1927

In spite of the obvious defects in the system there was a rapid improvement in the main turnpike roads between 1820 and 1835 largely due to the adoption of the methods advocated and practised by Mr J L McAdam and Mr T Telford, the two great road engineers of the period, each of whom constantly advised the appointment of skilled Surveyors adequately paid

By the year 1830 there were 1,100 Turnpike Trusts in the Country controlling 22,000 miles of relatively good roads, traversed daily by tens of thousands of mail coaches, post chaises and private carriages In that year the nation had come to be proud of its great lines of mail coach communication and travelling appeared to have been brought to a state of perfection. In 1837 the toll revenue rose to its highest point, exceeding one and a half million pounds

THE ADVENT OF THE RAILWAYS

Suddenly and with little warning there fell upon all concerned what has been described as the "calamity of railways" The Stockton & Darlington line was opened in 1825 and the Liverpool & Manchester line in 1830 These were so successful that they proved to be only a beginning of the complete supersession of passenger traffic by road and it was mainly this class of traffic that provided the revenue for the Turnpike Trusts. It has been computed that each stage-coach paid about £7 per mile per annum in tolls. The effect of the opening of the railways was immediate and the coaches disappeared The last coach between London and Bristol ran in 1843, the last from London to Plymouth in 1847. Many of the Turnpike Trusts became insolvent, could no longer repair the roads, and since the common law liability of the parish had never been taken

away, the burden of maintenance fell again on the parishes The Turnpike Trusts were gradually wound up, the last to be abolished being the Anglesey portion of the Shrewsbury and Holyhead Trust in 1895

THE GENERAL HIGHWAY ACT

In 1835 the General Highway Act was passed codifying the whole law in one Act which still retained the Parish as the unit of highway administration with salaried officers and *hired* labour instead of the former *statute* labour The Surveyor of Highways had power to levy a rate to meet the expenses By the Public Health Act of 1848 Local Boards of Health were formed for urban areas and the Boards were themselves made the Surveyors of Highways for all the roads within their districts The Highways Act of 1862 empowered Justices in Quarter Sessions compulsorily to combine parishes into Highway Districts under Highway Boards, the constituent parishes then losing the direct administration of their own highways though they had still to levy the rate to meet the precept of the Highway Board This Act, while striving for the enlargement of the impossibly small parish administrative area, did not produce general action. Some Quarter Sessions took action, others did not, and the work of combining parishes into Highway Districts was never completed The need for wider areas of highway administration became more and more insistent, and the Local Government Act of 1894 abolished both Highway Districts and Highway Parishes, merging them in the Rural Sanitary Authorities for their localities and constituting the present Urban District Councils and Rural District Councils The last surviving Highway Board disappeared in 1899 and by the end of the nineteenth century the responsibility of the Parish for its highways may be said to have disappeared

FIG. 8 —IMPROVED SURFACING, ARTERIAL ROAD, SOMERSET, 1930

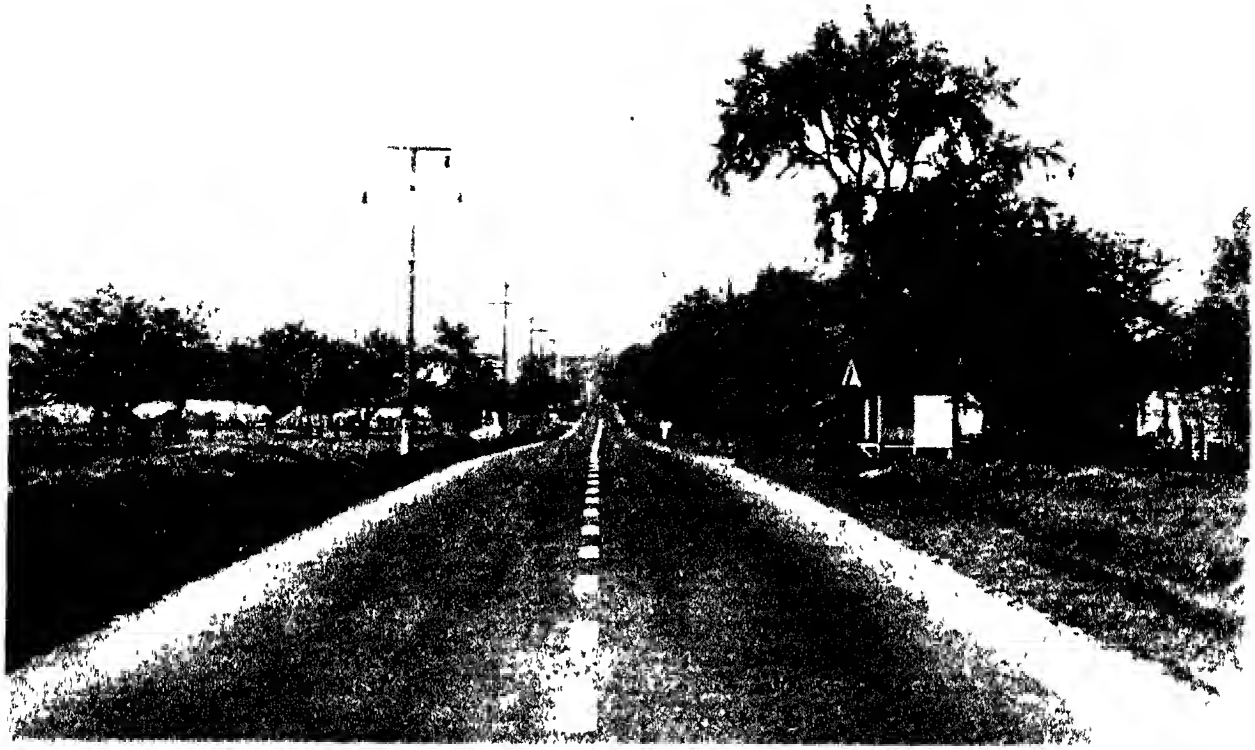


FIG. 9 MIXED MACADAM PAVEMENT, THE KING'S HIGHWAY ONTARIO, CANADA, 1930
(*Dept of Public Highways, Toronto*

THE HIGHWAY AND LOCOMOTIVES ACT

The continuous and rapid addition to the burden of highway maintenance borne by the Highway Boards and Highway Parishes by the transfer of thousands of miles of disturnpiked roads caused no little consternation and considerable resentment From 1876 onwards the Government made a grant in aid for the whole country of about £200,000 per annum specially to mitigate the burden of cost to the ratepayer in respect of the disturnpiked roads In 1878, by the Highway & Locomotives Act 1878, an attempt was made to adjust the remaining burden, as between the different parishes in the County, by requiring the Justices in Quarter Sessions to contribute from the County Fund one half of the annual cost of maintenance of roads disturnpiked after 1870. Under this Act County Surveyors of Roads were first appointed In 1888 the County Councils were created by the Local Government Act of that year, additional powers were given to the County by the State and they were required to pay the whole cost of maintaining "main" roads, with power to add to the disturnpiked roads such other roads as they thought fit to make main roads, and also to contribute at their discretion to the District Councils towards the repair of other roads in the County

Thus the stage was reached when the County Council became responsible for the entire upkeep of all main roads, and was empowered to make discretionary grants towards secondary roads, and the District Councils became responsible for the entire upkeep of all other highways

The elimination of the turnpike road and its tolls and the broadening of the area of road administration following the Acts of 1876, 1878 and 1888, together with the more skilful technical assistance available from the County Surveyors, produced greatly improved roads and all might perhaps have been well had there been no change in the character of the traffic on the roads So

FIG. 10 GERMAN MOTOR ROAD, 1930

(*Photo H S Ganderton*)

considerable a proportion of the commercial and passenger traffic was carried by the railways that the importance of the road even 45 years ago was very different from what it is to-day

The enormous change in road traffic may be traced to the industrial development of Europe and the great advance in mechanical science Although the first real bicycle appeared in 1867 it was not until about 1895 that bicycles became general Early attempts to apply mechanical traction to road vehicles, beginning in 1769, were beaten by the road conditions and later by the almost universal desire for travel by railway In 1896, however, there was passed the first Motor Car Act and for the first time a mechanically-propelled vehicle was allowed to travel by road without the "man and red flag" in front as was required by the Act of 1865 The combination of the bicycle and the motor car speedily demanded a revolution in road conditions and the cry for a hard smooth surface was raised on every hand A measure of "through" traffic appeared again on the roads for the first time since the advent of the railway The steady growth of this traffic until it has reached the dimensions with which we are all so familiar to-day needs no further description

THE DEVELOPMENT AND ROAD FUND ACT

With the coming of the motor car and its rapid increase the existing roads were soon found to be unsuitable The fast-moving traffic disintegrated and tore up the road surfaces, raising clouds of dust intensely annoying to the roadside dwellers as well as disagreeable to all travellers, and a fresh road problem was thus created Efforts were directed in the first place towards minimizing the awful dust nuisance and secondly to the strengthening and waterproofing of the road crust itself. These new requirements steadily increased the cost of road maintenance so that the Government was pressed to provide some measure of relief for

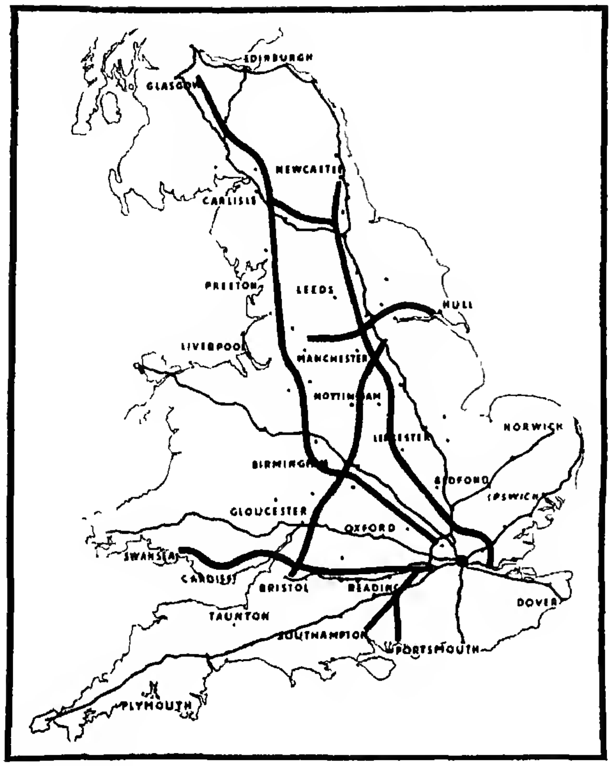


FIG 11 - COUNTY SURVEYORS' SOCIETY'S SCHEME FOR 1000 MILES OF MOTORWAYS

RECENT ACTS OF PARLIAMENT AFFECTING THE HIGHWAY SYSTEM

National assistance is now given towards the maintenance of roads as well as to improvements By the Trunk Roads Acts of 1936 and 1946, 8144 miles of the chief arterial roads have become a national responsibility with considerable relief to the local rates The actual work of repair and improvement is delegated by the Ministry of Transport to the County Boroughs and the County Councils The other roads of the country are divided into four classes according to their importance as traffic arteries Towards the first class the State pays 75 per cent of the annual cost of the ratepayer In 1909 the Development and Road Fund Act was passed setting up The Road Board and placing at its disposal for certain specific types of road improvement, but not for maintenance, the proceeds of a tax of 3d per gallon on petrol The Act of 1909 was a very important one, not only because it created the first National Road Authority, but because it placed at the disposal of the local authorities through the engineering staff of the Road Board the latest practice in road works, and at the same time made grants towards the costs. A very large amount of useful work was accomplished with the assistance of the Road Board During the two War periods 1914 1918 and 1939-1945 road development was arrested; many large and special works were undertaken solely for military purposes, but apart from these services efforts were concentrated on preventing as far as possible serious deterioration of the roads At the close of the Great War of 1914–1918 the Government created the Ministry of Transport, merging the Road Board in the Roads Department of the Ministry and greatly extending its powers

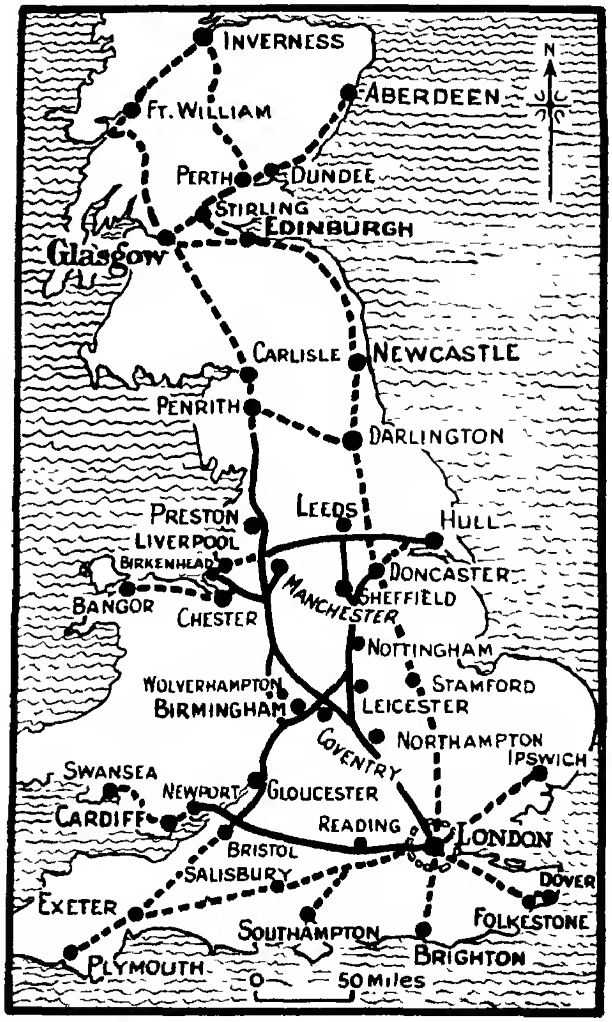


FIG 12—PROPOSED NEW ROAD PLAN FOR BRITAIN
Motor roads shown by thick black line, improved roads and by-passes by a broken line, and the suggested orbital road encircles London

(The Daily Telegraph)

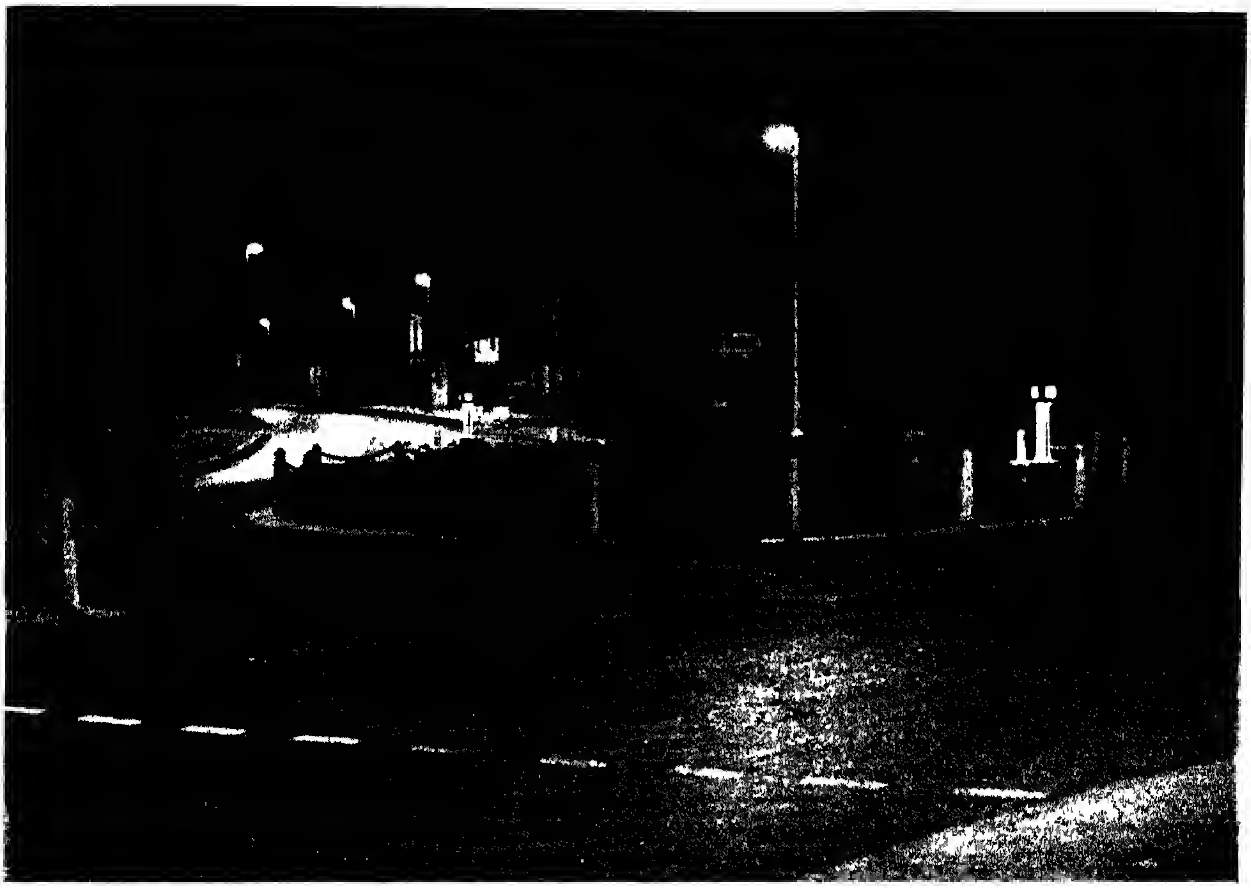


FIG. 13 THE APPROACH ROAD AND ROUNDABOUT AT HITCHIN, HERTS
Illuminated by 140-watt Sodium Discharge Lamps
(Engineering & Lighting Equipment Co. Ltd.)

maintenance and improvement, towards the second class 60 per cent and towards the third class 50 per cent, the cost of the fourth class remaining a local charge as before

In this comparatively short survey mention should be made of certain other legislation of importance to the well-being of roads, namely, The Roads Improvement Act 1925 which provides for the prescription of building lines and the prevention of obstruction to view at corners, The Local Government Act 1929, by which all highways in rural districts were transferred from the Rural District Councils to the County Councils; and the Restriction of Ribbon Development Act 1935 which places restrictions upon development along frontages of roads, provides for the preservation of amenities, and controls development in the neighbourhood of roads

PRESENT CONDITIONS

The standard of the surfaces of our roads is now generally admitted to be high, but so far as accommodation for present day requirements is concerned improvements have not kept abreast of the very considerable development of mechanical traffic It appears from the available records that in 1939 there were 3,182,000 road vehicles in Great Britain At that time the deficiencies of the highways were most obvious Unless, therefore, a very determined effort is made in the near future to improve conditions to meet the growing demand, the situation which may be created by 1965, when it is expected that 12,000,000 vehicles will be using the roads, must be viewed with extreme apprehension

In 1937 an influential British delegation which made an extensive tour of the German motorways was so impressed by the system then in operation that they subsequently forwarded to the Ministry of Transport and to the House of Lords Select Committee on Road Accidents a statement of the opinions and conclusions which they had reached, and *inter alia* expressing the view that the creation of similar motorways in this country would offer

striking national advantages in improved facilities of communication by road, economy of vehicular operation, speed of construction and reduced national expenditure.

In 1938 a diagram plan was prepared by the County Surveyors' Society showing specific proposals for motorway routes covering the whole of Britain with a total length of about 1,000 miles, and this plan, together with a memorandum giving full details of the suggestions was submitted to the Ministry of Transport. The scheme provided that the suggested motorways would by-pass the large towns, to which connection would be made by link roads, that access to the motorways would be restricted to junctions with main traffic arteries, and that minor roads would be carried over or under by bridges

FUTURE POLICY

The Government policy for the future development of the highway system, which it was hoped would put an end to much of the uncertainty that has hampered road engineers in the past, was outlined by the Minister of Transport in the House of Commons on the 6th May, 1946 The Minister submitted a highway programme covering ten years divided into three stages Stage 1 allows two years to be devoted to the overtaking of arrears of maintenance and the making good of damage by military traffic during the war but providing also for the improvement of particularly dangerous points. Stage 2 envisages three years for the completion of arrears of maintenance and continued activity on major road works of new construction, largely in development areas, among which high priority would be given to a limited number of motor roads This stage is of particular interest, indicating as it does the first action on the part of the Government towards the introduction of roads reserved for motor traffic into the British system of highways Stage 3 covers five years in which will be undertaken a complete and comprehensive reconstruction of the principal national roads Many of the existing roads pass through numerous towns and villages and are so restricted by frontage development or physical features that in the interests of safety, efficiency and economy it would undoubtedly be more satisfactory to construct new roads entirely reserved for motor traffic The preservation and safeguarding of amenities, both those existing and those likely to be affected, which would be an essential feature of new proposals—would be assured by complete liaison with the Ministry of Town and Country Planning

Fig 11 shows the County Surveyors' Society's scheme for motorways, as submitted to the Ministry of Transport, and Fig 12 the published map showing the Minister's proposed new motor roads and other improved roads Consideration of these two diagrams will disclose that there is a broad measure of agreement on the main proposals set out in each of them

The sections which follow—of which details are set out in the Contents—are the result of long experience and a careful study of materials, methods and processes of construction and indeed all the many problems which are likely to present themselves and which must be successfully dealt with if efficient construction, repair and management of the highway system is to be achieved.

Section One

PRELIMINARY SURVEYS

PRELIMINARY SURVEYS AND SITE INVESTIGATION

By J N McFEETERS, M Sc , M I C E , M I Struct E

SITE investigation is the obtaining of information in the field to enable the projected works to be located, designed, and carried out, in the most economical manner consistent with functional efficiency and with safety In its broadest sense it may cover many preliminary enquiries, such as traffic surveys, scheduling of land values, etc , in so far as these contribute to the decision to proceed with the work or to the choice of location In this section the term is confined to the investigation of alternative road alignments from the engineering point of view and to the detailed studies of the alignment finally selected The principles of reconnaissance and preliminary surveys are treated elsewhere in this volume and emphasis is accordingly placed on that branch of site investigation—the soil survey—which concerns the detailed investigation of the materials on which the road works will be built and of which the embankments will be constructed

The methods of soil mechanics enable the engineer to determine, within much closer limits than heretofore, the qualities and behaviour of the soil he uses or upon which he builds These methods depend on accurate measurements upon samples taken in the field or on tests upon the soil *in situ* Before describing the procedure for soil surveys the problems arising in road engineering will be mentioned along with some notes on the application of soil mechanics to determining the engineering properties of soils

It would be impossible in a short article to cover the whole range of sampling, measuring, and interpreting the results obtained, and it will be assumed that the reader will have available one or other of the first two references in the bibliography at the end of this article, which give detailed descriptions of the usual tests on soils Two other important references (3) (4) will also be available in the near future and should be consulted for further details

GENERAL SITE INVESTIGATION FOR ROADS

Road engineering presents the following main problems

a Pavements
b Embankments
c Cuttings
d Structures such as bridges
e Drainage

Even at its simplest, when the soil survey consists only in boring and inspection of samples of underlying strata, it can give useful information on all the above, for instance by indicating the suitability or otherwise of the soil for the proposed works, the presence of unseen difficulties, etc But when supplemented by the methods of soil mechanics it affords information which enables the skilled engineer, working in his office remote from the site, to pick out the salient problems of design from the unimportant elements and to design his works in an economical manner with due regard to safety He can also record for future consideration and comparison the foundation conditions under the completed works Such records, supplemented by those taken during construction, enable comparisons to be drawn between the behaviour of different forms of pavements, banks, etc and lead further to knowledge of design Another benefit lies in the possibility of studying the work of other engineers in the same forms of construction, as the soil data are reduced to a common "language" which can be interpreted by anyone familiar with it

While there is nothing to prevent any engineer from acquiring a working knowledge of the application of soil mechanics to his particular branch of work, a special part can be played by the soil specialist, in that being continually occupied in this field of study, he may frequently be in a position to draw conclusions from relevant cases which can be of the greatest assistance to the practising engineer

SOILS AND ROCKS

It has been stated above that soil mechanics affords a "language" expressive of the character of the soil deposits The basis of this language is the classification of soils into certain broad types which show characteristic behaviour when associated with engineering works This classification will be dealt with before proceeding to the methods of the soil survey and their applications.

The geological deposits which concern the engineer are soils and rocks, the former being

TABLE I

GENERAL CLASSIFICATION OF SOILS

		Simple Types: Name	Symbol	Field Identification		Important Types of Natural Deposits and Composite Types	Symbols See Table II
Particle size increasing	Non-cohesive Coarse Grained	Stones { Boulders, Cobbles	B*, C¹*	Most particles larger than 8 in diameter. Most particles less than 8 in and above 3 in diameter		Clay with boulders Gravel with boulders, etc	Symbol B or C¹ can be prefixed to any type below
		Gravels	G	Most particles less than 3 in and above $\frac{1}{16}$ in diameter (Between 3 in and No 7 sieves)		Sandy gravels well graded Sandy gravels poorly graded Clayey gravels (e g hoggin) well graded Clayey or silty gravels (e g hoggin) poorly graded; Gravel with excess fines	GW GP GC GF
		Coarse sands Medium sands Fine sands	S	Most particles lie between Nos 7 and 25 B S sieves Most particles lie between Nos 25 and 72 B S sieves Most particles lie between Nos 72 and 200 B S sieves Fine sands exhibit dilatancy	Particles visible to the naked eye No cohesion when dry	Shelly sands Well graded sands Poorly graded sands (with little or no fines) Well graded clayey sand Sand with excess fines, poorly graded clayey sand	 SW SP SC SF
	Cohesive Fine Grained	Silts	M (If organic O)	Most particles will pass No 200 B S sieve Some plasticity when moist Exhibit dilatancy May show slight cohesion when dry but can be powdered easily and dusted off the fingers Particles invisible or barely visible to the naked eye		Silt-fine sand mixtures of low-medium compressibility Organic silt (low-medium compressibility) Micaceous or diatomataceous silt (high compressibility)	ML OL MH
		Clays	C (If organic — O)	Large proportion of particles under 0 002 mm Smooth touch and plastic when moist and sticks to fingers No dilatancy Considerable cohesion when dry Shrinks appreciably on drying, frequently showing cracks Dry lumps can be broken but not powdered They also disintegrate under water		Sandy or silty clay (low-medium compressibility) Highly plastic clay (inorganic) of high compressibility Organic clay of high compressibility	CL CH OH
		Peat	Pt	Fibrous organic material usually brown or black in colour		Sandy silty or clayey peats	SPt* MPt* CPt*

Note - Symbols marked thus * are suggested for the first time

W Well graded, coarse grained soil
P Poorly graded coarse grained soil
L Fine grained soil of low compressibility
F Fines (Implies poor grading)
O —Organic
H —Fine grained soil of high compressibility

derived from the latter by weathering, with or without transportation. Soil consists of comparatively "soft and loose deposits" and rock of "hard and rigid deposits"(3). Top Soil, i e that part of the soil which supports plant growth, is not referred to here

CLASSIFICATION OF SOILS

Table I shows a classification which is adapted from those proposed by the Code of Practice Committee on Site Investigation and which is believed to be specially appropriate to the problems of road engineering It will be observed that the basis of the classification is the general character of naturally occurring deposits, rather than mere particle size, since the names for the main types, gravel, sand, clay, etc , are not confined to particles of a certain size but to soils where particles of defined sizes play a leading part in determining how the soil behaves This is in accordance

TABLE II

CHARACTERISTICS OF SOIL TYPES IN ROAD AND EARTHWORK CONSTRUCTION

Note—The figures given are not to be taken as defining the soil characteristics but as indicating typical values encountered

			COMPACTION DATA					SUB-GRADE DATA				
Soil Type	*Nature of soil*	*Designation*	*Typical max density lb/cu ft*	*Typical optimum moisture content %*	*Compaction Characteristics and suitable Equipment*	*Desirable moisture content*	*Remarks*	*Value as Road Foundation or subgrade when not subject to frost action*	*Drainage Characteristics*	*Typical California Testing Ratio Soil compaction and soaked specimens*	*Typical Modulus of Subgrade reaction for saturated soil in place lb/sq in/in*	*Comparable Groups in Public Roads or A A S H O classification (for reference only)*
GRAVEL AND GRAVELLY SOILS	**Sandy gravel, well graded, fairly clean**	GW	130	8	Excellent Tractor, Smooth roller	Wide range		Excellent	Excellent	> 40	500–2000	A 3
	Sandy gravel, poorly graded, fairly clean	GP	120	9	Good Tractor	Wide range		Good to excellent	Excellent	25–40	270–500	A 3
	Clayey gravel (e.g. hoggin) well graded	GC	135	8	Excellent Smooth roller, Sheepsfoot roller	Near to optimum	Heavy rollers are useful	Excellent	Practically impervious	> 40	400–700	A 1
	Gravel with excess of fines, clayey or silty gravel (e.g. hoggin) poorly graded	GF	125	12	Good Sheepsfoot roller, pneumatic-tyred roller	Near to optimum	Close moisture control essential	Good to excellent	Fair to practically impervious	> 20	250–400	A 2
SANDS AND SANDY SOIL	**Sand well graded fairly clean, little or no fines**	SW	125	9	Excellent Tractor pneumatic-tyred roller	Approaching saturation	Ponding or vibrating may be successful	Excellent to good	Excellent	20–60	230–500	A 3
	Sand poorly graded fairly clean, little or no fines	SP	105	10	Good Tractor, pneumatic-tyred roller	Approaching saturation		Fair to good	Excellent	10–30	200–270	A 3
	Clayey sand, well graded	SC	130	9	Excellent Sheepsfoot roller	Near to optimum		Excellent to good	Practically impervious	20–60	230–500	A 1
	Sand with excess of fines, poorly graded silty or clayey sand	SF	110	14	Good Sheepsfoot roller, pneumatic-tyred roller	Near to optimum	Close moisture control essential	Fair to good	Fair to practically impervious	8–30	180–350	A 2
SOILS CONTAINING LITTLE OR NO COARSE-GRAINED MATERIAL	**Silt-fine sand mixtures of low-medium compressibility including clayey fine sand**	ML	105	16	Good to poor Pneumatic-tyred roller	Near to optimum	Close moisture control essential	Fair to poor	Fair to poor	6–25	160–230	A 4 A 6 A 7
	Organic silt low-medium compressibility	OL	95	18	Fair to poor Sheepsfoot roller	Near to optimum	Undesirable for Earthworks, 100% relative compaction desirable as minimum with close moisture control	Poor to very poor	Poor	3–8	100–180	A 4 A 7
	Micaceous and diatomaceous fine sandy or silty soils, elastic silt	MH	<100	—	Poor to very poor	—	Very undesirable for Earthworks	Poor to very poor	Poor	< 7	100–180	A 5
	Sandy or silty clay of low-medium compressibility	CI	105	20	Fair to good Sheepsfoot roller	Near to optimum	Pressures on Sheepsfoot roller should be as high as possible Close moisture control essential	Fair to poor	Practically impervious	4–15	130–230	A 4 A 6 A 7
	Highly plastic clay (inorganic) of high compressibility	CH	95	26	Fair to poor Sheepsfoot roller	Near to optimum	Undesirable for Earthworks, 100% relative compaction desirable as minimum with close moisture control	Poor to very poor	Fair to poor	< 6	50–160	A 6 A 7
	Organic clays of high compressibility, (Medium-high plasticity)	OH	<100	—	Poor to very poor	—	Very undesirable for Earthworks	Very poor	Practically Impervious	< 4	50–130	A 7 A 8
Peat, Fibrous organic soil with very high compressibility		Pt	—	—	Compaction not practicable	—	Quite useless for Earthworks	Extremely poor	Fair to poor	—	—	A 8

with common usage and engineering experience, though laboratory practice is made to assist by helping to fix the limits of each group in a manner that can ultimately be checked by standard tests. Thus, a clay is defined as a soil having a large proportion of particles less than 0·002 mm in size and having the properties of plasticity, fine grain, stickiness, etc. with which engineers are acquainted, instead of being idealized as one whose mechanical analysis lies entirely below the 0·002 mm size—a soil which is seldom, if ever, encountered. The wording "clay fragment"* is applied in the latter sense, i.e. of strict mechanical analysis. Similarly we have "silt", as distinguished from the "silt fragment", "sand", from the "sand fragment", etc.

The table goes on to enumerate certain special cases of the main (i.e. simple) soil types, including composite types which could arise from their mixture in different proportions, and which are met in naturally occurring deposits. Symbols are given to these according to a classification first suggested by Dr Arthur Casagrande for road and airfield work applied with success both in America and in this country. The special properties of these further types are set out in Table II, based on a table prepared for the U.S. Corps of Engineers (9), with certain modifications.

BEHAVIOUR OF SOILS

Passing to the "behaviour" of soils and considering the two main groups of Table I, viz. *coarse-grained* and *fine-grained* soils, it is seen that

* It is suggested that if the wording "clay" or "silt", etc. is ever used in the sense called here "clay or silt fragment", it should be printed thus "CLAY", "SILT", to distinguish it from the natural deposit.

TABLE III

NORMAL PROPERTIES OF COARSE- AND FINE-GRAINED SOILS

Coarse-grained soils (sand and gravel)	*Fine-grained soils (clay and silt)*
Particles mostly visible	Particles mostly invisible
Non-cohesive	Cohesive
Frictional	Non-frictional
Non-plastic	Plastic
Relatively pervious	Relatively impervious
Compressibility low	Compressibility frequently high
High maximum relative density	Low maximum relative bulk density
Consolidation under load usually almost completed when building work is finished	Consolidation under load frequently takes place over long period

the very important property of cohesion belongs to the latter (the clays and silts) while the coarser grained sands and gravels are practically non-cohesive. Conversely, the sands and gravels have considerable internal friction, except when loosely packed, while clay and silt have very little. The differentiation of the groups in this respect is fundamental since their mechanics is entirely different. It is not possible to go into all the individual qualities of the various soil types, but Table III shows certain broad characteristics of coarse- and fine-grained soils. Their differences extend to the composite soils, and a sand with a large proportion of clay "binder", or matrix, may behave in many respects as a clay does. Such a type might be described as a sandy clay (CL), while if the proportion of sand were greater, leading to behaviour more allied to the coarse-grained

TABLE IV

FIELD TESTS FOR DISTINGUISHING CLAY, SILT, AND FINE SAND†

Clay	*Silt*	*Fine Sand*
Particles mostly invisible Smooth greasy touch Sticks to the fingers and dries slowly	Particles mostly invisible Rough texture, but not gritty Dries very quickly, and can be dusted off the fingers	Particles mostly visible Definitely gritty Dries moderately quickly, and can be dusted off the fingers, leaving only a stain
Non-dilatancy‡ Dry lumps can be broken but not powdered in the fingers	Definite dilatancy‡ Dry lumps have appreciable cohesion, but can be powdered between the fingers	Definite dilatancy‡ Dry lumps may have some slight cohesion, but can be very easily powdered between the fingers
High plasticity	Some plasticity	No plasticity

† Slightly adapted from the article on "Particle Size in Silts and Sands" (See Bibliography, page 45)

‡ To test the property of dilatancy a small wet pat is shaken in the hand, in a silt some of the pore water will appear on the surface, but on pressing the pat between the fingers the water will be drawn back and the surface become dry. In clays neither phenomenon is present.

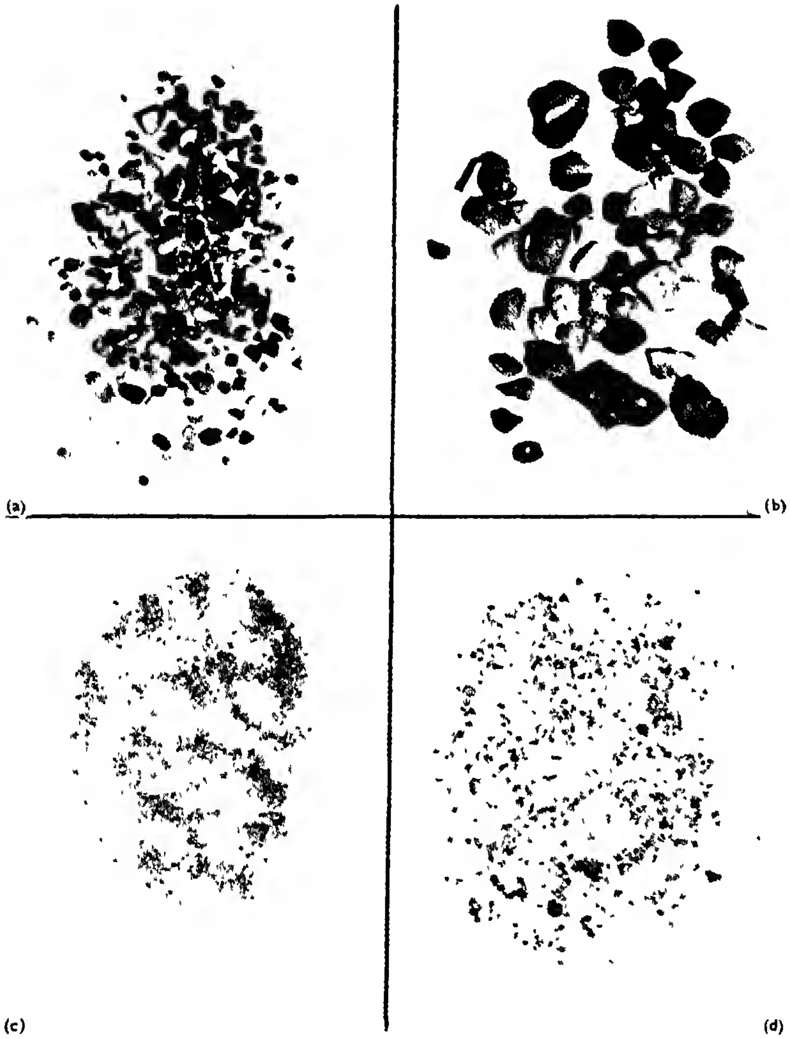


FIG. 1 TRUE-TO-SCALE PHOTOGRAPH OF SANDS AND GRAVELS
(*a*) COARSE SAND (*b*) FINE GRAVEL, (*c*) FINE SAND, (*d*) MEDIUM SAND
(Reproduced by permission of the Director of Building Research Crown Copyright reserved)

group, the soil might be described as a clayey sand (SC or SF)

The classification of coarse-grained soils is frequently easy and may often be done by visual inspection only Fig 1 shows a true-to-scale photograph of sand and gravel particles which will assist in recognition Fine sand is a borderline case and the clays, silts, and fine sands are liable to confusion Table IV sets out information already given in Table I so as to show certain distinctions between these groups as determined by simple field tests

In the case of composite types or soils which lie on the borders of two types it may be necessary to analyse the sample mechanically by means of sieving or by sedimentation analysis (of the finer materials) to determine the grading of the particles and hence the group into which the soil will fall Such an analysis is plotted as in Fig 2, which shows the grading curve or mechanical analysis of a soil from an African dirt road

For the finer soils, the test for grouping can be carried out more simply by ascertaining the liquid and plastic limits, sometimes called the Atterberg limits These "index" tests are fully described in references (1) and (2) in the Bibliography, page 45, but briefly the plastic limit is the lowest water content of the soil, expressed as a percentage of its dry weight, at which the soil will remain plastic It is found by rolling under the hand a thin thread of the soil to a diameter of about one eighth of an inch and repeating until the lowest water content is found at which this can be done The liquid limit is that higher water content, also expressed as a percentage of the dry weight of the soil at which the soil ceases to be plastic and becomes just liquid It is determined by the flowing together of a groove, cut on the surface of a small specimen of the soil, after 25 blows in a standard machine The arithmetical difference of the liquid and plastic limits is called the "plasticity index" and represents the range of water content in which the soil remains plastic

These tests form a very convenient index to the cohesion of the soil and to many allied properties, such as clay content and the properties of the clay fraction, etc In Fig 3, the fine soil groups of Table II are plotted against the liquid limit and plasticity index, thus enabling the soil type to be determined by the simple tests described above In mixed soils the index tests are done on the fine material passing the No 36 sieve and should be considered with reference to the proportion of the whole which passes that sieve

DISCUSSION OF THE CLASSIFICATION FOR FINE AND COARSE-GRAINED SOILS

In the draft Code of Practice for Site Investiga

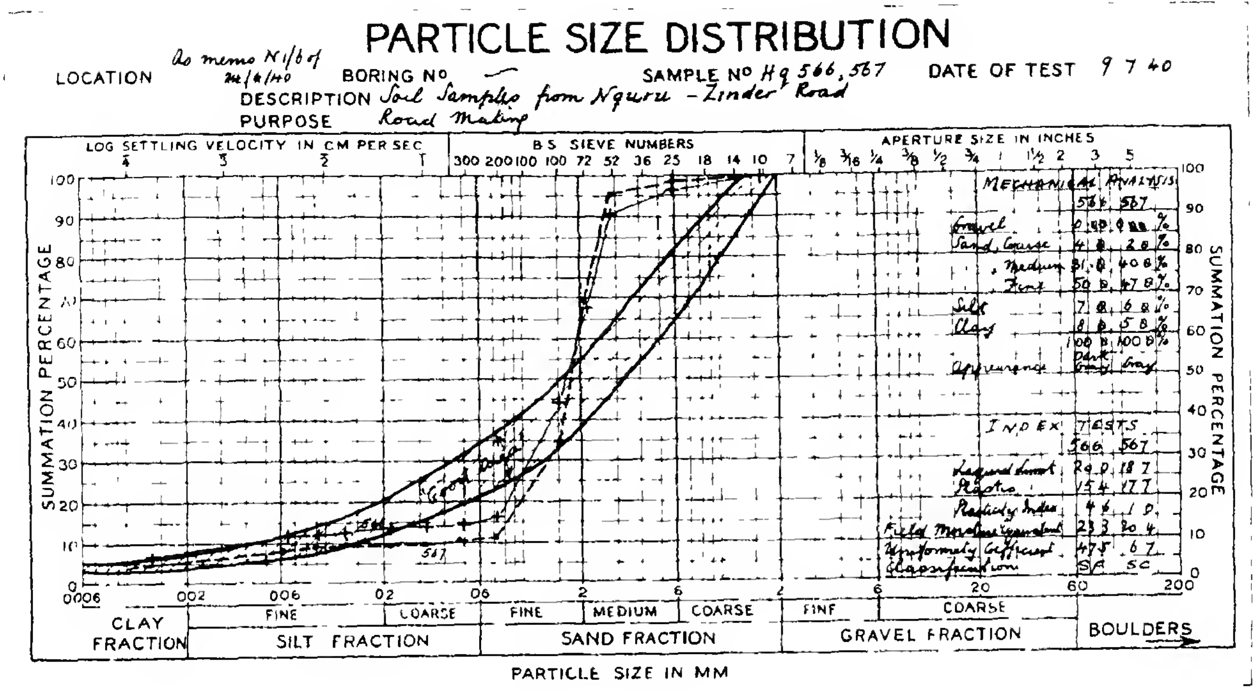


Fig 2 Grading Curve or Mechanical Analysis of Soil from an African Dirt Road

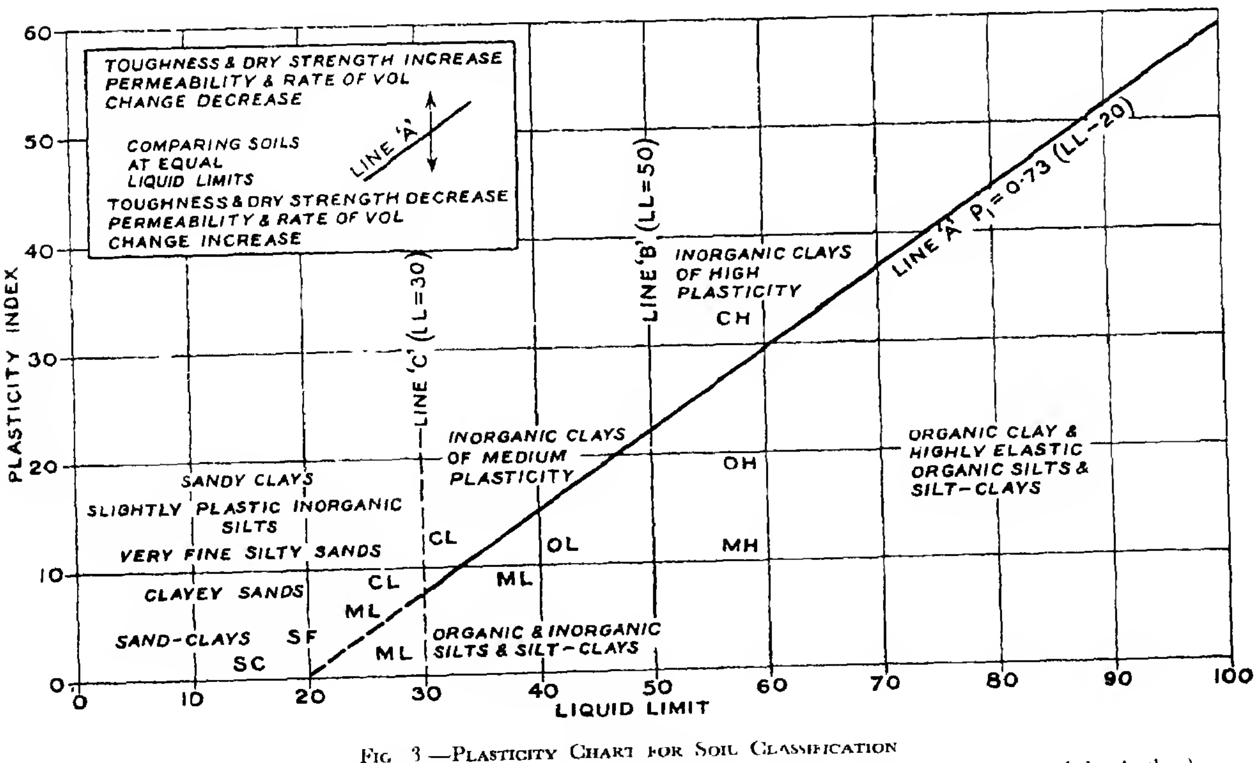


Fig 3 —Plasticity Chart for Soil Classification
(Prepared by Dr Arthur Casagrande for the U S Corps of Engineers, reproduced by permission of the Author)

tion, a classification similar to that of Table II is only recommended for use with disturbed soil. On road work this would lead to a dual system of nomenclature, in that undisturbed soil of the same particle-size distribution would have to be described at length, on the basis of its type, strength, structural features, and colour. While it is desirable to record these characteristics in addition to any classification adopted, and to the statistical description afforded by the results of tests, it is felt that the Casagrande classification should be used for all soils, whether disturbed or not, met by the roads engineer The latter is, of course, at liberty to introduce for his personal problems, any further classification which may suit his local materials, and it may be that after some experience, a general classification especially suited to roads in this country may be derived This time lies far ahead, however, and the suggested classification is of great usefulness on road and airfield works

It should never be forgotten that a pavement is a continuous foundation with no superstructure This must be investigated in an entirely different manner from the foundations of a building, which are of relatively small extent and which have to support an expensive superstructure Buildings, bridge piers, etc merit investigation in great detail which is best comprehended when set out in the form of a quantitative analysis Road work requires broader treatment and the very diverse soil conditions frequently met with are best reduced to a limited number of distinct groups, as proposed here, based fundamentally on their behaviour under similar conditions

THE INFLUENCE OF "GRADING" ON SOIL BEHAVIOUR

In Table II "well graded" and "poorly graded" soils are differentiated and may fall into different types, even when their main constituent type is the same Thus "well graded" sands are classed as SW and "poorly graded" sands as SP The difference between the two groups may be traced by following them through the remaining columns of Table II. Practising engineers are well aware that a sandy soil with a good grading will "roll up" well, while, if the sand is "all one size" it is much more difficult to compact under the roller, and a less dense filling results. It is difficult to form a hard and fast rule as to the "goodness" or otherwise of the grading, but the simplest test is by inspection of the grading curve Uniform or good grading would be indicated by the shaded area of Fig 2 which shows steadily increasing particle size The specimens whose grading curves are plotted in this diagram have a much more irregular distribution mainly due to high content of FINE SAND, i e particles in the size range 0 006-0·2 mm (See footnote on page 29) The tendency would be to class them as equally poorly graded, were it not for their liquid limits and plasticity indices. Referring to Fig 2 it would appear that Specimen 566, though a borderline case, is probably an SF soil while 567 is on the borders of an SC, i e a well-graded sand clay. It is interesting to note that in the field these were distinguished as follows 566 "Swampy"; 567 "Motor Wheels do not make track after heavy rain"

It was on the basis of this different performance that they were sent to the laboratory for test and the close correspondence of their gradings was surprising The subsoil permeability may have had something to do with their different behaviour. Nevertheless, in their classification, there is some basis for belief that the performance of the latter will be superior to the former The Uniformity Coefficient test sometimes recommended (3) should be used with great reserve as it may be likely to cloud the issue For instance 566 has a Uniformity Coefficient 8 times that of 567, which would indicate better grading for 566 This is more than offset by the slightly higher CLAY* content and perhaps the shape and chemical composition of the CLAY particles, leading to worse performance Further sampling and testing would be required to decide the point

PEAT

The last member of the soil types in Table I—peat—has not been mentioned as yet Peaty soils are characterized by high compressibility when loaded and are also liable to large changes in volume when dried out, as may occur after exposure or when a period of moderate loading has expelled water They are sometimes described as useless for foundations but it might be truer to say that they can be very dangerous as such, while they are useless for filling

In cases of necessity, as when the peat deposits have been too deep to remove, roads constructed over peat have given satisfactory service over a number of years Raft foundations, etc , for bridges, have also been founded on peat layers, where relatively uniform settlement has not been an objection Peat frequently occurs in pockets and is perhaps most dangerous in this form as it gives

* See footnote p 29

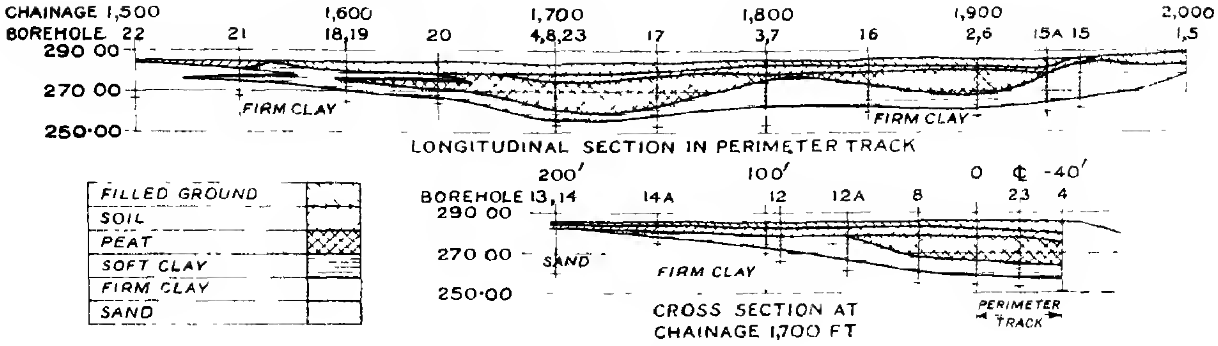


Fig. 4 Soil Profile of Peat Beds

rise to differential settlement. Peat should be most carefully looked for in surveying an area where it is liable to occur, and the boundaries and depth of all pockets should be accurately located. If at all possible, peat should be avoided entirely, either by choice of another location, or by removal of peaty layers. If this is impossible, appropriate measures will have to be taken in the design of road and drainage works. Fig. 4 shows a case of peat which occurred on an airfield. This might have been avoided by better location of the perimeter track, had an adequate soil survey been made in advance.

CLASSIFICATION OF ROCKS—THEIR IMPORTANCE

Table V gives the classification of rocks suggested in the draft Code of Practice for Site Investigation.

In road works, the occurrence of rock may give rise to considerable expense when excavating cuttings or drains. Location of rock may also be of importance in connection with the foundations of bridges. Occasionally, as in the case of roads cut along the sides of gullies or cliffs, the quality of the rock as a foundation, and the slope it will safely stand at, must be taken into account. This applies especially to shales, limestone and chalk.

In proving rock, it is necessary to ensure, by sufficient borings, that boulders are not mistaken for bed-rock. Certain rocks, such as shales and limestones, may be interbedded with clays and in the case of important foundations trial holes or rotary drilling may have to be employed to determine the stratification. In excavation problems it is the bedding and jointing of the rock which will decide whether explosives will be required, or whether the rock can be shifted by bars, rooters, or explosives. Trial pits may be required to enable the condition of the joints and beds to be examined.

In general it is sufficient to classify the rock by description of its type (as in Table V), its condition, i.e. whether sound, weathered, etc., and the nature, direction and inclination of its beds and joints. It is seldom necessary to carry out loading tests on rock, as it usually suffices for the foundation loads imposed on it. The behaviour of chalk or shale when subjected to water may have to be investigated in connection with the slopes of cuttings, or when used as filling material near the top surface of banks. There is no standard test for

Table V

CLASSIFICATION OF ROCKS

Group	*Class*	*Rock Type*
Crystalline	Igneous	Granites Dolerites Basalts
	Metamorphic	Gneisses Some Schists
Sedimentary	Arenaceous	Siliceous sandstones Calcareous sandstones Ferruginous sandstones Argillaceous sandstones
	Argillaceous	Clayey rocks such as Hard Shales, Slates and some Schists
	Calcareous	Massively-bedded limestones Thinly-bedded limestones Chalk

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this and the engineer should draw his inferences from the amount of "break-down" which takes place after soaking, combined with appropriate loading tests while moist

CONDITION OF SOIL OR ROCK

In addition to the type of soil it is necessary to know the *condition* in which it exists *in situ*, i e its water content, density, structure, etc These may be estimated from simple field tests, as described on pages 39 and 40, or, more elaborately, by determining the water content and density of specimens as described on page 42 It will be clear that fine-grained soils in particular will vary in their performance according to their water content, even where the type is uniform.

Clearly, while the type is fundamental, the water content may be affected by seasonal changes or permanently altered by drainage, pavement construction, etc ; the density similarly, may be increased by rolling or decreased, e g where adjacent soil is removed when forming the slope of a cutting To describe a soil it is necessary to know both its type and condition

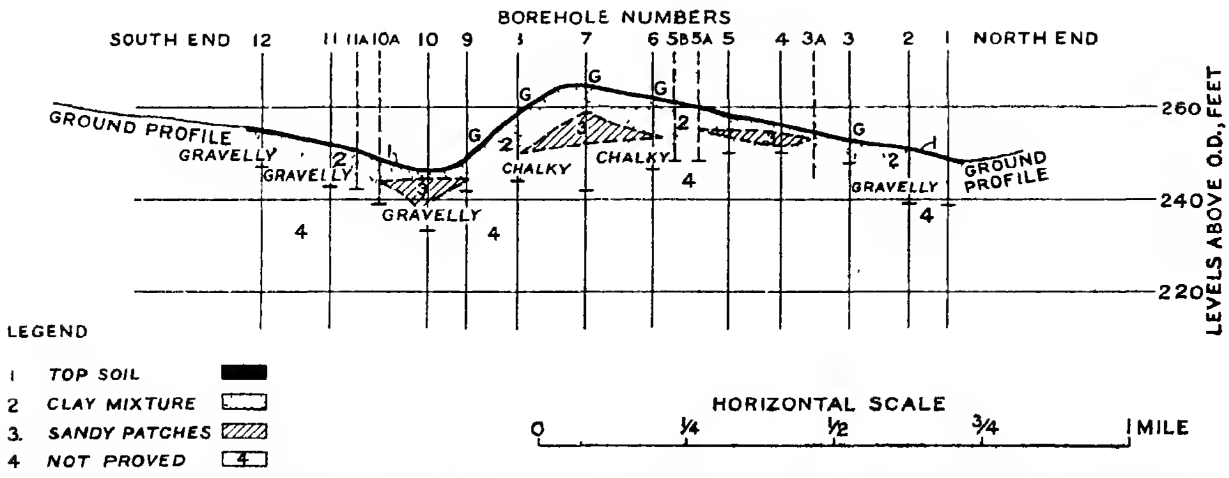
SOIL SURVEY, GENERAL METHODS

A soil survey is carried out by taking borings at selected points and recording the strata encountered These are plotted to appropriate scales on longitudinal and cross sections and joined by continuous lines as shown on Figs. 4, 5 and 6 The resulting sections are called the *soil profile.* A simple soil profile is shown in Fig 5.

The soil strata are, in the first case, given a field nomenclature such as "Soil A", "Soil B", etc., and described as to approximate type and condition in the field engineer's note-book or on the boring records, but samples are taken of all strata as described below and tested in the laboratory, as a result of which they may be shown on the final drawings by the type-symbols of Tables I and II while the field classification is amended as necessary and recorded for detailed reference

It is not possible to indicate how many borings are required on road surveys, as the spacing will vary according to the information required and the variability of the soil types On many road jobs it will be sufficient to take a single line of borings on, or parallel to, the centre line of the proposed location Occasionally, these may be supplemented by more detailed local surveys Some locations, particularly on cross-falling ground, or with steeply inclined horizons between the strata, may require a double line of borings, parallel to the centre line On "detailed surveys" (as defined later), 200-ft longitudinal intervals may be tried for a start, unless the geological indications favour closer spacing

It may be necessary to return and take intermediate borings to locate the point where certain beds disappear (see Fig 5), which shows the



NB THE TOP SOIL CONTAINS APPROXIMATELY 5–10% GRAVEL EXCEPT WHERE MARKED BY THE LETTER G WHEN THE PERCENTAGE INCREASES TO 20–40%
BORES MARKED WITH LETTERS A&B TAKEN AFTER COMPLETION OF ORIGINAL SURVEY TO LOCATE LIMITS OF SAND BEDS

FIG 5.—SIMPLE PROFILE OF ROAD

advisability of carrying forward the plotting of the profile as the borings are taken. Squared paper is the best medium upon which to do this and suitable scales might be 50 ft to the inch horizontally and five feet to the inch vertically The squared paper should be prepared by plotting on it the proposed formation level of the road For pavement surveys, a depth of boring of 5 ft below the finished formation level is required on areas of cut, or where the road is at natural ground level On areas of fill, some judgment is required and geological information can be of assistance

An embankment constitutes a localized surcharge As such, it may be necessary to explore to a depth of one and a half times the average width (or even the full width) of the bank, to determine whether weak underlying strata are liable to cause settlement On the other hand with shallow fills on ground of reasonably uniform stratification and fair quality, deep exploration may be unnecessary The borings on all areas should extend below the line of the drainage ditches and through any pervious bed below that level to the first bed which would block percolation In cases where the formation level is not decided, sufficient depth should be explored to allow for possible variations of design

Much more detailed borings are required where structures are to be built The general rule in such cases is to bore to $1\frac{1}{2}$ times the least width of the bridge pier or of any raft Further details should be sought in Ref (6) of the Bibliography on page 45

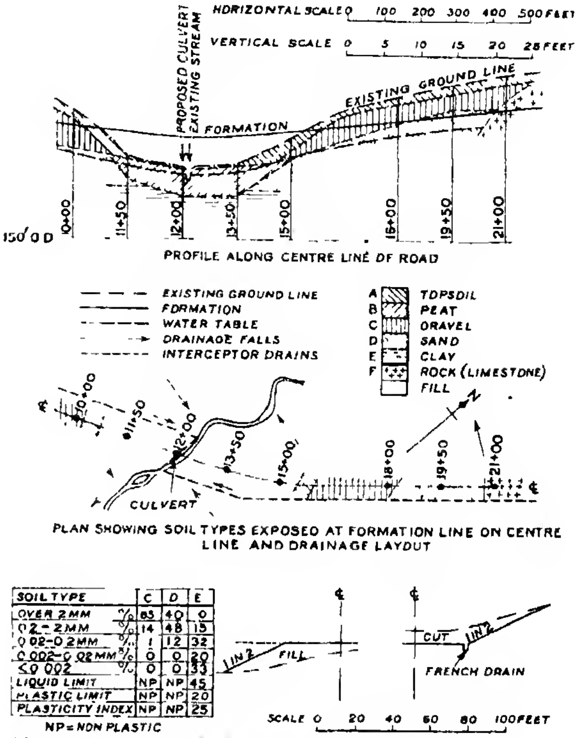
The location of borings need not be as accurate as the location of surface detail or of survey or level points It will usually be sufficiently accurate to locate bore holes by pacing from the nearest hedge line or other surface feature Surface levels may be recorded to the nearest 0 1 ft Depths should be taken to the nearest inch

TYPES OF SOIL SURVEY

There are three main types of soil survey, viz

1 In connection with the trial location of new roads (Preliminary Survey)
2 The detailed survey of one or more trial lines of new road which have been selected from general considerations, including, where available, information obtained from 1
3 The detailed survey of existing roads in connection with their improvement or with an examination of their failure.

The distinction drawn between types 1 and 2 envisages the possibility that the preliminary location may be made without investigation of sub-soil conditions Where possible, this should be avoided, but there are cases, as on road diversions, where alternative lines are not available and the problem is to make the best of fixed conditions There are also cases, as on very uniform deposits of which the engineer already



SOIL TYPE		C	D	E
OVER 2 MM	%	85	40	0
0 2–2 MM	%	14	48	15
0 02–0 2 MM	%	1	12	32
0 002–0 02 MM	%	0	0	20
<0 002	%	0	0	33
LIQUID LIMIT		NP	NP	45
PLASTIC LIMIT		NP	NP	20
PLASTICITY INDEX		NP	NP	25

NP = NON PLASTIC

TESTS ON CHIEF TYPES OF SOIL

N B ALL TOPSOIL (TYPE A) IS TO BE PRESERVED AND USED FOR SOILING AT THE COMPLETION OF THE WORK
ALL PEATY SOIL (TYPE B) IS TO BE CUT OUT AND REPLACED BY APPROVED FILLING
ALL FILLING TO BE SPREAD AND ROLLED IN LAYERS NOT EXCEEDING 9 IN.
SAND TO BE SPREAD 2 IN THICK AS A SUB-BASE

FIG 6 —SOIL PROFILE SUITABLE FOR CONTRACT DRAWING
(Reproduced by permission of the Director of Road Research Crown Copyright reserved)

has experience or evidence, when the trial line or lines can be laid out and levelled before exploring the ground beneath In general, however, 1 and 2 will both be required, i e. 2 will become the obtaining of information to supplement that already available from 1.

PRELIMINARY SURVEYS

In this type of survey, the boring party will frequently work ahead of the levelling party, and will leave pegs for the latter to level upon, should it be decided that the subsoil is good enough for a

trial location Formation levels will, in the main, be undetermined, and it will be necessary to ensure that the borings are deep enough to cover possible variations of cut and fill A lot will depend on the terrain as to the detail required in this preliminary survey In difficult ground with rapid variations e g where pockets of peat are likely to occur, closely spaced borings will alone give information of value, and then depth must be sufficient to explore the dangerous beds On the other hand, in uniform ground, other considerations than soil variations are likely to decide the location, and the preliminary survey may consist of borings at widely spaced intervals, or at such spots as river crossings, or it may be omitted entirely

Detailed Survey of Trial Lines

The detailed investigation of trial lines will differ from the preliminary soil survey in that a trial formation level will usually be available, which will enable the depth of all borings to be decided upon, while the spacing of borings will also be easier to fix since the positions of cuttings and embankments will be known In this case, the level party will have left bench marks which will be used by the boring party to level off, and station points of the survey may be used to fix chainages Where alternative lines are being investigated it must be assumed that importance will attach to the results or it would only be necessary to explore the line preferred on other counts Some detail will therefore be required

In either of the above cases, the boring party, while in the field, may be used to find the best location, since the information they obtain may decide the engineer to swing the road around difficult subsoil conditions In order to locate better ground, it may be necessary to take a series of borings perpendicular to the road or even to carry out a grid of borings to right or left of the original location

Detailed Survey of Existing Roads

This is of course a "detailed" survey and the disposition of the borings must be related to the information required If, for instance it is designed to throw light on the incidence of cracking in the slabs, it would be based on a survey of these cracks and might require borings at close intervals in selected areas (*a*) where cracking was most severe and (*b*) where cracking was non-existent Alternatively it might have special reference to areas where sub-soil water was suspected, etc , etc

COLLECTION OF INFORMATION PRIOR TO TAKING BORINGS

The golden rule in a site investigation is to collect as much preliminary information as possible by reference to published maps and reports, by enquiries addressed to all authorities likely to have detailed knowledge of the site, and finally by enlisting local knowledge The information obtained should be carefully sifted and in case of doubt it is clearly better to explore rather than "take for granted"

Geological Survey

The most important source of information is the Geological Survey The officers of this department are most generous in their help Their records, published and unpublished, and their frequently detailed local knowledge, will often help the engineer to decide on the best course to be pursued It is sometimes thought that the superficial nature of pavement construction makes geology unimportant This is not so

A case in point is given by the experience gained on some repairs to runway works A tarmacadam runway had been constructed, rather from aeronautical than geological considerations, where "the geological outcrop was in the nature of a line running across the runways, so that there was a côral rag (a rubbly limestone) on the left,

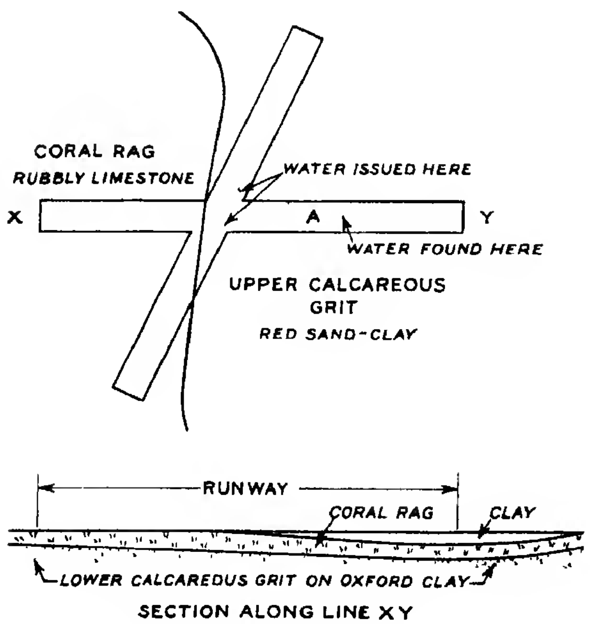


FIG. 7 — RUNWAY OVERLYING CORAL RAG AND CALCAREOUS GRIT
(Reproduced by permission of the Council of the Institution of Civil Engineers)

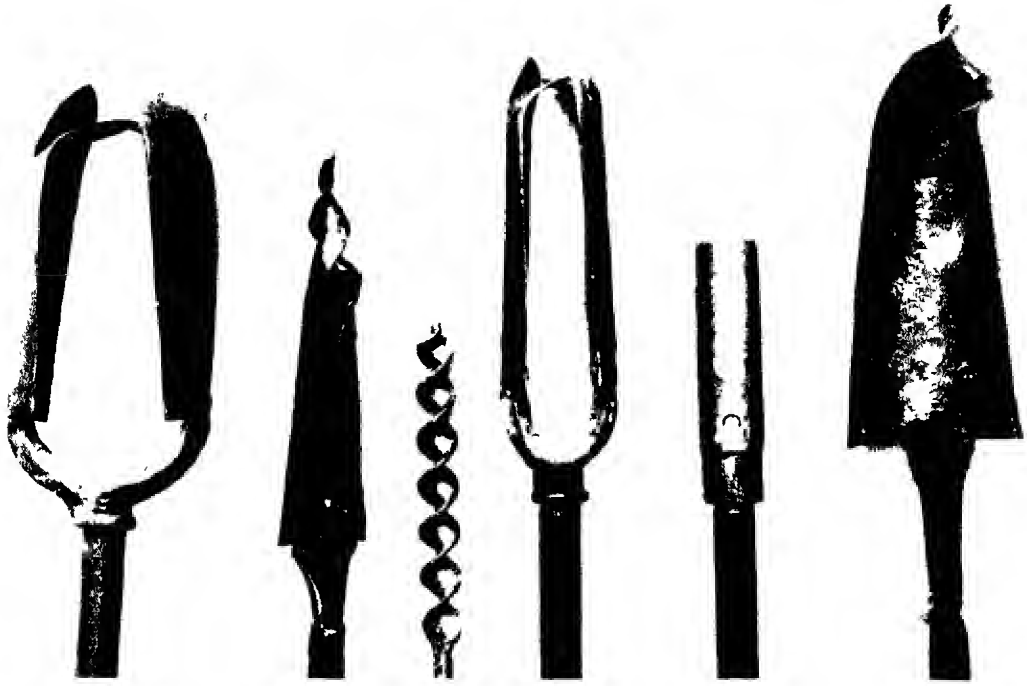


FIG. 8.—HAND BORING EQUIPMENT

Reading from left to right, 1. 5-in Post Hole Auger 2. 2-in Gravel Auger 3. 1¼-in Corkscrew Auger 4. 3-in Post Hole Auger 5. 1½-in Sampling Tube mounted on boring tube 6. 5-in Gravel Auger

and calcareous grit, which was largely clay on the right" * (See Fig 7) Where founded on the coral rag, the runways gave perfectly satisfactory service but troubles quickly arose on those portions which were founded on the clay The consulting engineer who was called in to investigate "soon found that the cause of the trouble was the peculiar geological characteristics of the site The coral rag allowed the water to enter into it, and it was cut off on the under-side by the lower calcareous layer, so that there was hydrostatic pressure acting upwards against a thin band of clay which was the only protection for the tarmac runway constructed on its surface At a particular point, after very heavy rains, numerous jets of water were found to issue upwards through the tarmac, owing to the hydrostatic pressure of the water down below At another point, water was found within an inch or two of the surface and an old ordnance map showed a stream actually rising at that point "*

The diagnosis was made purely on existing geological records combined with surface inspection and was afterwards confirmed by trial excavations For a fuller description and methods of curing the trouble, see the Institution of Civil Engineers Road Paper No 15, of May 1944, page 24 *et seq*

One inch Geological maps of the whole country are available in two series, one showing solid deposits, the other, surface drift deposits Both series should be consulted along with all relevant memoirs, which may be seen at the offices of the Geological Survey, South Kensington, London, S W 7, and at some local branches of the Geological Survey as well (It is almost impossible to obtain geological maps at present, as reserve stocks and also many records were destroyed by enemy action) 6-in geological maps of a large part of the country are also available for consultation Quarter-inch maps are also issued and 10 miles to the inch maps in "solid" and "drift" series are in preparation

ORDNANCE SURVEY

The Ordnance sheets of 1 in to the mile, 6 in to the mile, 25 in. to the mile or 1/2500 (with its 1/1250 and 1/500 enlargements for certain urban areas) are well known to engineers The 25 inch scale is probably the most useful for showing construction lines and drainage, but the 6 in maps are particularly good for mapping the catchments of

* Extracts from discussion by Mr J Kennard, M I C E, on "The Construction of Pavements on a Clay Foundation Soil", by Rudolph Glossop, B Sc, A R S M, and Hugh Quintin Golder, M Eng, Assoc M Inst C E, by permission of the Council of the Institution of Civil Engineers

streams, in connection with the study of groundwater and drainage. The directional arrows of tributaries should be ascertained from the 25 in. maps. When laying out new roads over open farmland it is frequently of great assistance to study the earliest 25 in series available, as the location of old hedges and ponds, which have since been removed or filled in, will give a clue to likely difficulties

TABLE VI (on foolscap)
SURVEY INSTRUCTION SHEET

SOIL MECHANICS LABORATORY
FIELD AND LABORATORY INSTRUCTIONS

Lab Sheet No ____________

Field Sheet No ____________

FIRM ____________ PROJECT ____________ JOB NO ________

SITE ____________ DEPARTMENTAL REFERENCE ____________

AUTHORITY FOR WORK ____________________

WORK TO BE CARRIED OUT IN FIELD BY ____________

GENERAL

BORINGS (Location, Number, Depth)

SAMPLES (Location, Number, Weight, Purpose)

SHEAR TESTS

MODULUS OF SUB-GRADE REACTION

COMPACTION TESTS

Further details to be shown on reverse side of sheet

WORK TO BE CARRIED OUT IN LAB BY ____________

GENERAL

NATURAL MOISTURE CONTENT

INDEX TESTS

MECHANICAL ANALYSIS

OPTIMUM MOISTURE AND DENSITY

STABILIZATION

Further details to be shown on reverse side of sheet

Copies to ____________

____

____

____

Signed ____________

Date ____________

In mining areas reference should be made to the Coal Commission (present headquarters 25, Chester Square, London, S.W.1), for details as to workings.

PRELIMINARY RECONNAISSANCE (NEW WORKS)

As a result of information obtained prior to starting the survey, it should be possible to decide upon the approximate location, spacing and depth of borings, and upon other matters such as tests required and samples to be taken This trial programme should next be checked by walking over the site and noting all features 6-inch maps are particularly useful at this stage as notes can readily be made and useful detail is shown, e g the margins of areas liable to winter floods can often be estimated closely from the markings on the map and from the contours Flood marks, such as debris in hedges, can then be looked for together with indications from the nature o the crops or the shape of fields

The 1-in map is not satisfactory for detailed field work though it has usefulness when used in conjunction with the 6-in map The 1-in geological survey sheets, if available, are, however, most useful field maps, particularly on areas where solid deposits outcrop, and enable the engineer to see many aspects of his problem more clearly

The preliminary reconnaissance may be combined with preliminary location, or it may be carried out with reference to the soil survey only In either case it should begin with an examination on foot of nearby roads, and an inspection of other soil exposures such as railway cuttings, quarries, etc , since the notes made as a result of this examination will enable the engineer to spot the likely occurrence of similar soils or rocks from the topographical features on his own location

Next, the proposed location should be walked over, paying special attention to signs of groundwater, occurrence of soils, changes of vegetation which indicate changes of soil or moisture, signs of soil movement on slopes, geological features, faults, sites where soil may be borrowed, etc At the conclusion of this reconnaissance, the information available should be reviewed once more and the final scheme for the soil survey prepared.

At this stage it is desirable to prepare detailed instructions on sheets such as Table VI indicating the information required, the borings and samples which are to be taken and, on the same sheet, the laboratory tests which will be carried out. This gives the engineer in charge of the boring party a clear picture of what is required

Table VII

EQUIPMENT REQUIRED FOR SOIL SURVEYS

NOTE —*Equipment necessary depends on site conditions and frequently some of the items listed can be omitted*

FOR SETTING OUT

- 1 Theodolite (can often be omitted)
- 1 Level (preferably a quickset type with Tacheometrical cross hairs)
- 1 Levelling staff
- 1 Field Book
- 1 Level Book
- 12 Chaining arrows Supply of pegs, painted white at the top
- 1 100-ft steel tape (or one 100-ft chain) and one 100-ft metallic linen tape
  The latter is sufficient if preliminary survey has already been done
- 6 Ranging rods
- 1 Axe
- 25 in to mile Ordnance Sheets covering area

FOR BORING —(*Assuming two sets in use simultaneously on same site*

- Supply of boring record sheets
- 2 Post-hole augers 4 in with ¾ in gas pipe connections
- 2 Post-hole augers 5 in with ¾ in gas pipe connections
- 1 Gravel auger
- 1 Sand pump or shell with self-closing flaps
- 1 Twist auger 1½ in diameter
- 2 Chisels (one diamond shaped) capable of being connected with the auger extensions
- Sufficient 3-ft lengths of ¾ in gas pipes as extensions for 2 augers to work at maximum depth Preferably with etched foot marks
- Supply of sample tins numbered and greased (including tins for large samples)
- Supply of ointment tins (or airtight bottles with snap covers) for small moisture content samples
- 3 Spatulas, two 4-in, and one 8-in
- 2 Spades (for clayey ground)
- 2 Shovels (for sandy ground)
- 2 Picks
- 2 Sledge hammers, 4 lb and 7 lb
- 2 Engineer's hammers
- 4 Stillson wrenches
- 2 8-in Plasterer's trowels
- 1 Plumb bob
- 1 Focusing Electric Torch (to illuminate hole or test pit)
- 1 Van (10 cwt)
- Boxes about 15-in cube to carry sample tins say
- 6 Sacks
- Labels (tie-on and stick-on)
- String and rope
- Thick oil for greasing lids of tins, and extension joints
- Thin oil for greasing sampling tubes
- Bottle of HCl for identifying limestones
- Packing Materials
- Roll of adhesive tape for sealing tins
- Chinagraph pencils for marking sample boxes
- Squared paper for plotting profiles while on the site
- Camera
- Notebooks, pencils, etc
- Drawing instruments
- 5-ft rule
- Adapter head to fix sampling tubes to ¾-in gas pipes
- 12 Sampling tubes 1½ in diameter
- 2 Mandrils for extruding specimens from tubes
- Paraffin wax

SPECIAL EQUIPMENT FOR OTHER TESTS

- Unconfined compression apparatus complete with springs, masks, specimen shapers, etc
- Plate bearing test apparatus complete with jacks, gauges, etc and lorry for loading
- Density apparatus including core-cutter with extruder and sand bottles Gardener's trowel for last

For deep borings or borings in difficult ground a complete set of well-boring kit is required, see manufacturers' catalogue

For consolidation tests, two or more undisturbed sampling tubes of 4¼ in diameter are required, to fit on boring rods

EQUIPMENT FOR SOIL SURVEYS

Table VII gives a list of the equipment required for a comprehensive soil survey In some cases this may be reduced to a minimum of augers and sample tins only. A van is almost a necessity, however

Fig 8 shows the most useful types of auger together with a sampling tube for unconfined compression tests fitted to the boring pipes Experience alone will teach the use of the augers in getting out the hole. The results of borings should be recorded on a sheet such as that shown in Table VIII. Careful note should be taken of ground water and in rainy weather it may be necessary to distinguish this from surface water by baling and observing over a period Rates of seepage into the hole should be recorded Rate of percolation may sometimes be required and can be determined by pouring water into the hole and noting how long it takes to empty The results should be interpreted with caution

FIELD BORINGS

Many difficulties will be met in taking borings in the field, especially in connection with the securing of representative samples. It would be impossible to give instructions which could pretend to cover all likely difficulties It is frequently necessary to abandon holes owing to the presence of boulders or gravel and to try again nearby In wet ground it may prove impossible to bring up samples in the tube, though baling by means of

TABLE VIII (on foolscap)

BORING SHEET

Field Sheet No

SOIL MECHANICS LABORATORY

BORING RECORDS

FIRM ________ PROJECT ________ JOB NO ________

SITE ________ DEPARTMENTAL REFERENCE ________

Bore No	*Date*
Location	*Chainage*
Natural Ground Level	*Change to Formation*
Water Level A O D	*W L Depth below Surface*
Remarks	

Date and Time	*Depth below surface* *ft*	*in*	*Sample No*	*Water seeping into hole*	*Bottle No*	*Auger used*	*Description and Remarks*

Samples taken by ________

Signed ________

Date ________

a tin on a wire may help In waterlogged sands and silts and sometimes in fine dry sands, it may be impossible to get down without lining tubes, and this is usually a job for a well-boring firm who carry the necessary equipment

It is not always possible for the engineer to be present at each boring, and a trained leading labourer will lay out the material extracted from the hole in the order in which it was lifted, drawing a line to represent each foot of depth, so that the engineer may inspect later. It is, however, advisable for the engineer to "see for himself" as far as possible, since the value of the information depends on the accuracy of the depth measurement and the visual examination of the sample as raised. In the case of structures, special care is required to locate contiguous beds of fine-grained and coarse-grained soil. An important example is that of the "varved clays", i e interbedded thin layers of clay, silt and fine sand, which cause particularly difficult consolidation problems In the borings, such laminations may come up together in a more or less mixed condition, especially under water, and it requires trained observation to recognize the probable bedded structure.

Labourers—and frequently well-borers—may describe as clay a soil which will turn out to be preponderantly fine sand, care is required to insist on adequate samples of all strata in any case where, for reasons outside his control, the engineer is forced to make use of a well-boring firm without full-time supervision by a trained member of his own staff There are, of course, certain specialist firms to whom the taking of borings and the testing of samples may be entrusted

Description of Soils and Rocks

Soils encountered should be fully described by the engineer taking the borings and the following system should invariably be used It is substantially that recommended in the Draft Code of Practice for Site Investigation

- i Type of Soil
- ii Strength
- iii Structural Characteristics
- iv Colour
- v Moisture
- vi Peculiar Smell

Type of Soil.—The nearest broad group as given in Table I should be estimated from field inspection, without using the group symbol The description will be modified if necessary and a symbol assigned as a result of the subsequent laboratory examination.

Strength.—The following definitions should be used:

A. Coarse-grained Soils

- ***a*** *Loose*: can be excavated with spade 2-in peg can be easily driven
- ***b.*** *Compact*: requires pick for excavation 2-in. peg hard to drive for more than a few inches.

c *Slightly cemented* determinable by visual inspection Pick removes soil in lumps which can be abraded with thumb

B FINE-GRAINED SOILS

a *Very soft* when squeezed in fist, exudes between fingers.
b *Soft* easily moulded in fingers
c *Firm* can be moulded by strong pressure of fingers
d *Stiff* cannot be moulded in fingers
e *Hard* brittle or very tough

C PEATS

a *Firm* *b* *Spongy*

Structural Characteristics

A COARSE-GRAINED SOILS OR STONES

a *Uniform* deposit consisting essentially of one type
b *Stratified* alternating layers of different types

B FINE-GRAINED SOILS

a *Fissured*
b *Intact* i e non-fissured
c *Uniform* as above
d *Stratified* as above
e *Weathered* Usually exhibits crumb or columnar structure

Colour —The colour should be stated

Moisture—The words dry, waterlogged, etc, should be added where appropriate, unless a separate description of ground water conditions makes this superfluous

Peculiar Smell—Any peculiar smell, whether due to the presence of excess organic matter, or otherwise, should be noted

Examples of such field descriptions would be

(*a*) Clay, stiff, fissured, grey, slightly moist, faint smell of sewage (*b*) Shelly sand, loose, coarse, stratified, brown, wet

SAMPLES

Samples consist of two sorts—disturbed and "undisturbed" Truly undisturbed samples are not obtainable, but relatively undisturbed samples of certain soils can be obtained. They are required for compression, consolidation, and shear tests (see below). Disturbed samples are suitable for all identification tests, tests of water content, and of standard compaction For many problems connected with subgrades and embankments, disturbed samples will give the engineer all the information he requires, while the comparatively simply-taken undisturbed sample for the unconfined compression test will cover most of the remaining problems in pavements and cuttings in clay soils The larger undisturbed samples are required in connection with consolidation studies for bridge piers, and investigations as to the stability of sands They are usually a matter for specialists to take and analyse Further information can be obtained from the Bibliography (ref 1, 2, 3) Only the simpler types of sampling are referred to here

Samples should be taken of all strata encountered, or, in uniform material, at about two feet intervals in depth Disturbed samples may be taken off the auger parings or from inside the valve auger, and placed in sample tins or jars In the case of unconfined compression tests on plastic soils (see below) it will be necessary to replace the auger with the 1½ in diameter sampling tube shown in Fig 8 Sampling tubes are driven into the soil at the bottom of the bore hole by hammering the boring pipes (suitably capped or socketed to protect the joint) with a sledge hammer, or by jacking The tube is usually oiled to reduce friction An alternative method of securing samples in a relatively undisturbed state is to cut large samples from the sides or bottom of a trial pit and trim to the required size

Density tests *in situ* are only performed on superficial layers accessible by digging, or in trial pits Large specimens, such as those required by relative compaction tests, are dug out from representative points in the subgrade or in the deposits to be used for earthworks Table IX shows the size of sample required for various tests, such as

TABLE IX
SIZE OF SOIL SAMPLE REQUIRED†

Purpose of sample	*Soil type*	*Minimum weight of sample required*
Soil Identification and Natural Moisture Content Tests	Cohesive soils and sands	1½ lb
Ditto	Gravels	7 lb
Compaction Tests	Cohesive soils and sands	10 lb
	Gravelly soils	20 lb
Soil stabilization sand-mix	Ditto	10 lb
Other types	Ditto	½–1 cwt

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could be done in a small laboratory set up by a local authority The large sample in the last line of the Table refers to the case when a relatively uniform deposit occurs on the subgrade or in a borrow pit proposed for filling It is useful in such cases to have a large sample in the laboratory for repeat tests; the name "representative sample" is used below for such large samples, which may be dug from one selected point in the deposit or carefully made up from smaller samples dug at various points Large samples are also required for soil stabilization studies

Samples should be placed in air-tight tins or jars as soon as secured and the lid should be sealed with oil or paraffin wax and adhesive tape so as to prevent the entry of air Reference numbers should be indelibly marked or stamped *on the jar or tin* as the lids are liable to be interchanged While a fair proportion of samples may only be used for visual inspection, it is better to assume in the first case that a water content and index tests may be required on any sample taken It is therefore preferable to enclose them all in air-tight containers as described above In view of the number of samples on a road survey, tins with lever lids will probably be found more convenient than jars, except for waterlogged samples A convenient size of tin is 2½ by 3½ in diameter Cadmium-plated ointment tins are suitable for small specimens for water content tests

Hand samples from trial holes may be carried in larger air-tight tins, or may be coated with paraffin wax to exclude the air. Tube samples for the unconfined compression test should, where possible, be extracted and tested on the spot Otherwise, the tube should be sealed both ends with paraffin wax and sent to the laboratory intact, as, if specimens are extracted and coated with wax they may swell owing to the relaxation of pressure in comparison with their condition underground, and the strength measurements may be affected

Larger disturbed samples, such as "representative samples" for compaction testing may be carried in a sack, though this is unsuitable for fine, sandy material which may escape in transit Special care is required that labels are securely attached to sacks, and duplicates should be placed inside and not mixed after arrival.

Water contents should be taken on all proposed samples—which should be as many as possible—as soon as they arrive. Samples to be used for identification or compaction testing should be thoroughly mixed and "quartered"* the process being repeated until the right size of sample is obtained. It is wrong to take part of a sample without quartering or otherwise thoroughly mixing, as it may not be representative of the stratum at the point from which it is taken

* See page 235 of Reference (2) of Bibliography.

SPECIAL TESTS WHICH MAY BE PERFORMED IN ADDITION TO THE SOIL SURVEY OR IN CONJUNCTION WITH IT

The soil survey is frequently confined to classification of the underlying strata as outlined above Tests of strength relationships, etc , may be considered by some to lie outside the range of ordinary engineering and to be a matter for specialists Some of them, however, notably density and unconfined compression tests, are quite easily taken after a little practice, and are of great usefulness in many road problems A brief summary is given of these and of other significant tests For details, reference should be made to Items (1) or (2) of the Bibliography

1 Natural Water Content

This is determined by drying out the specimen and weighing before and after. The weight of water is expressed as a percentage of the dry soil weight This test throws light on the *condition* of the natural soil and is necessary along with the soil type to give a picture of the probable behaviour of the soil during construction, or after completion, of the works It should therefore be undertaken on as many samples as possible

2. Density Tests

a. Natural Soil Density

This serves to determine whether earthworks have been sufficiently compacted or whether natural subgrades can be improved by additional compaction The method consists of removing a portion of soil of about the size of a tumbler from the ground to be tested, ascertaining the volume of the hole and estimating the dry weight of the soil removed by obtaining its weight and the moisture content of a small portion, leading to the "dry soil density of the soil *in situ*", which is one of the most useful figures in the control of earthworks

b Standard Compaction Test

It is now becoming well known that, *if the amount of work done on a soil is kept constant*, as when the same number of equal blows of a standard rammer are applied to specimens of the same soil, there is one water content, the "optimum", at which the dry soil density will be maximum. The corresponding maximum density is called the

Proctor optimum density and is often used as a standard to determine the degree of compaction which should be achieved on earthworks The optimum density which can be achieved in the test (or in the field) differs with different soils and can be used as a measure of their suitability for earthworks (1)

3 STRESS-STRAIN OR STRENGTH TESTS

(*a*) *Unconfined Compression Test* —This is confined to cohesive soils and indicates their permissible bearing value under pavements and foundations The shear strength equals the unconfined compression strength ÷ 2 and is used in the design of slopes of earthworks. The samples for this test are easily taken during the survey and the apparatus is inexpensive and portable Applications are described in ref (1) and (6) of the Bibliography

(*b*) *Shear and tri-axial tests* —These are used in the design of foundations and earthworks with coarse-grained or mixed soils Sampling and testing require expert assistance

(*c*) *Consolidation tests* —These are used to determine the long-term settlement of structures on plastic soils, and require expert advice

(*d*) *Modulus of Subgrade Reaction* —This is used in the design of concrete pavements by the Westergaard method A plate, usually of 30 in diameter is jacked into the proposed subgrade and the pressure required to give a depression of 0 05 in is measured or estimated The modulus (k) is defined as pressure per square inch of plate, per inch of depression (lbs inches ^{3}) *

(*e*) *Loading or bearing tests* are sometimes used in the design of foundations They consist of measuring the depression of the soil *in situ* under a directly applied load which is increased in increments to a value well above the proposed foundation pressure The results require very careful interpretation

(*f*) *California Bearing Ratio tests* —This is an empirical test which can give information as to the requisite thickness of non-concrete pavements The conclusions are drawn empirically from the penetration of a standard plunger into the soil, whether sampled or *in situ*, both in its natural concondition and when saturated †

4 STABILIZATION TESTS

These can be used to ascertain the suitability of the soil for stabilization with cement or chemicals, and the amount and type stabilizer required ‡

GROUND WATER INVESTIGATIONS

Records of the incidence of ground water are kept during the survey In addition it may be advisable in the region of certain structures, of culverts, and of areas requiring special drainage, to extend the survey to give a picture of the ground water levels and directions of flow In such cases, the ground water levels should be plotted both as contours and as depths below ground, and special attention should be paid to any apparent inconsistencies in the records §

DETAILED INFORMATION TO BE OBTAINED FROM THE SITE INVESTIGATION

The application of the results of soil tests to the design of road works is outside the scope of this section but it may be useful to summarize under the heads (*a*) to (*e*) of the paragraph headed "Site Investigation for Roads General", (see page 26) the main information which can be obtained from the soil survey and the supplementary tests described above

(*a*) PAVEMENTS

Avoidance of unsuitable subgrades (e.g peat) and of areas subject to waterlogging in winter Choice of compaction methods for subgrades Possibility of subgrade improvement by addition of other aggregates or soils or by stabilization Choice of concrete or flexible main course Design of thickness of pavement

(*b*) EMBANKMENTS

Choice of suitable filling Selection of borrow pits Information as to stability of foundation, suitable side-slopes, etc. Control of compaction Suitable equipment

(*c*) CUTTINGS

Indication of rock or difficult ground to be encountered during excavation. Information as to safe side slopes.

* See page 188 of Ref (1) in Bibliography
† See Ref (1) in Bibliography
‡ See references (1) and (8) in Bibliography
§ See page 126 of reference (1) and reference (7) of Bibliography

TABLE X (on foolscap)

REPORT SHEET

Report Sheet No

SOIL MECHANICS LABORATORY

REPORT ON RESULTS OF TESTS

To ____________________

____

Lab Sheet No ____________

Job No ____________

Sample Nos ______ *to* ______

FIRM

SITE

PROJECT

DEPARTMENTAL REFERENCE

AUTHORITY FOR WORK

FIELD WORK CARRIED OUT

LABORATORY INVESTIGATION

REMARKS (for details see overleaf and attached sheets______)

Signed____________

Date ____________

(*d*) STRUCTURES

Safe bearing values Possibility of long term settlements. Hidden difficulties with underlying beds Constructional difficulties with excavations.

(*e*) DRAINAGE

Ground-water levels and directions of flow. Areas likely to cause trouble owing to these and to soil types Location and spacing of drains

On projects for the renovation of old roads, additional information is obtained, throwing light on the causes of failure and leading to improved design and to the best choice of remedial measures

COST OF SITE INVESTIGATION

This will vary widely according to the site and the information required It also depends on the proportion carried out by the engineer's own staff as against that done by contract The latter is apt to prove more expensive but may be required for special or difficult investigations On clay soils, an engineer and two labourers can do up to 60 lin ft of shallow boring per day On soils which are difficult to penetrate, by reason of gravel, boulders, or running sand, 20 ft per day might be good progress More or less standard charges have been fixed for the main tests by the recognized soil laboratories, and estimates for these should be obtained when working out the probable cost of investigations Even at its most expensive, the soil survey cannot cost more than a small percentage of the construction cost, and the benefits are incalculable.

TABLE X (contd)—(reverse side)

RESULTS OF TESTS

Job No ——

Site - -

Details of Samples tested				*Natural Moisture Content*	*Field Density*	*Optimum Moisture Content*	*Compacted Density at Optm Moisture*	*Liquid Limit*	*Plastic Limit*	*Plasticity Index*	*Shear Strength*	*Modulus of Subgrade Reaction*	*Californian Bearing Ratio*	*Mechanical Analysis*				*Soil Classification*	*Remarks*
Field Ref	*Lab Ref*	*Location*	*Depth ft in*	%	*lbs/ft³*	%	*lbs/ft³*	%	%	%	$\frac{U.C.S.}{2}$ *lbs/in²*	*lbs/in³*	%	*C*	*M*	*S*	*G*		

REPORT AND CONTRACT DRAWINGS

The report should summarize the information as clearly as possible. The positions of all boreholes should be shown on the plan and cross sections and all samples should be marked in their correct positions. It is not sufficient to show a sheet of boreholes, as is done in foundation work, but soil profiles should be drawn up, as already described. All soils should be classified, and notes should indicate the proposed treatment of each soil as part of the contract arrangements. The test data should be summarized in some convenient form and be supported by numerical test results (see e.g. Table X). The drawings should be finalized and worked up into a suitable form for inclusion in the contract documents (Fig. 6). Samples of certain soils should be made available to persons tendering, and thereafter to the site staff for recognition purposes.

SOIL SURVEY DURING CONTRACT

Further data should be collected during the contract and the original survey amended as necessary.

ACKNOWLEDGMENT

Particular indebtedness is expressed to references (3) and (7) of the Bibliography. Differences from the tentative recommendations of the former are expressed where it seemed necessary in view of the special problems of road engineering.

BIBLIOGRAPHY

(1) "*Soils, Concrete and Bituminous Materials*." (A record of an instructional course given to officers of the R.A.F. Airfield Construction Service at the Road Research Laboratory, D.S.I.R., July-August 1943.) H.M. Stationery Office, Price 10s. 6*d*.

(2) "*Standard Specifications for Highway Materials and Methods of Sampling and Testing*," Part II. American Association of State Highway Officials, 1220 National Press Building, Washington, D.C.

(3) "*Code of Practice for Site Investigation*." (*Civil Engineering and Public Works*.) Committee convened by the Institution of Civil Engineers on behalf of the Code of Practice Committee. Draft. In preparation for print.

(4) *British Standard for Tests on Soils*. British Standards Institution. In preparation.

(5) R. Glossop and A. W. Skempton. "Particle Size in Silts and Sands." *Journal of the Institution of Civil Engineers*, No. 2, 1945-46. December, 1945. (Crown Copyright reserved.)

(6) L. F. Cooling, "Soil Mechanics and Site Exploration." *Journal of the Institution of Civil Engineers*, 1942, 18 (5), 37-61.

(7) D.S.I.R. Road Research Laboratory, "*Soil Surveys and Ground Water Investigations on Road and Airfield Construction Sites*." Note No. RN 406 AHDM SBW. August, 1943.

(8) Institute of Petroleum, "*Report on Tests for Soil Stabilization*", No. 7. Asphaltic Bitumen.

(9) *Soil Tests for the Design of Runway Pavements*. T. A. Middlebrooks and G. E. Bertram. Proc. Highw. Res. Bd. Wash., 1944, **22**, 144-73.

NEW DEVELOPMENTS IN SURVEYING INSTRUMENTS

(These notes have been compiled jointly by COOKE, TROUGHTON & SIMS, LTD., LONDON, S W.1, and E R WATTS & SON, LTD, LONDON, S E 5)

THE modern surveying instrument, whether theodolite or level, bears little resemblance to its counterpart of a hundred years ago (see Fig. 1) While, on the whole, progress has been fairly steady, it is a single recent development, applicable to both, which is largely responsible for the decided improvement in their efficiency, simplicity of operation and compactness of design; a big step has been taken with the use of glass for the divided circle and the inclusion of an optical system for reading the circle divisions

As a material on which to graduate, glass has proved itself infinitely superior to metal, for it can be engraved more accurately and with finer graduations The brilliantly illuminated field of view, only possible with a transparent circle, and the very high magnification to which the sharply contrasted graduations can be subjected, permit very accurate readings to be taken without strain on the observer The protection afforded by the total enclosure of all working parts is an added advantage; moreover circles of glass can be made so much smaller than those of metal that their use has effected a considerable reduction in the size and weight of instruments

Optical Systems

Various types of optical systems have been developed These range from the simple prism and eyepiece for the horizontal circle on the surveyor's

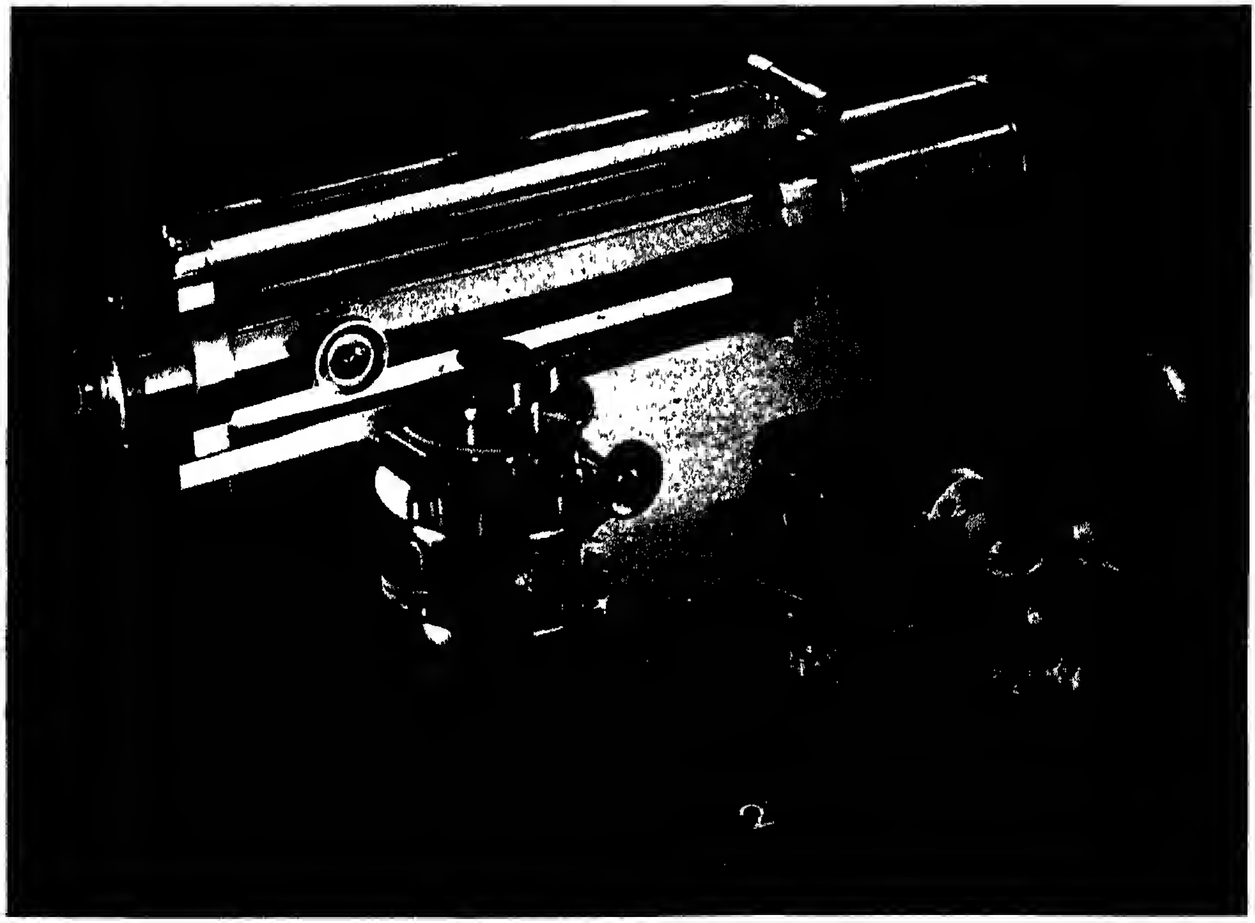


FIG. 1.—SURVEYOR'S LEVELS OF 1846 AND 1946

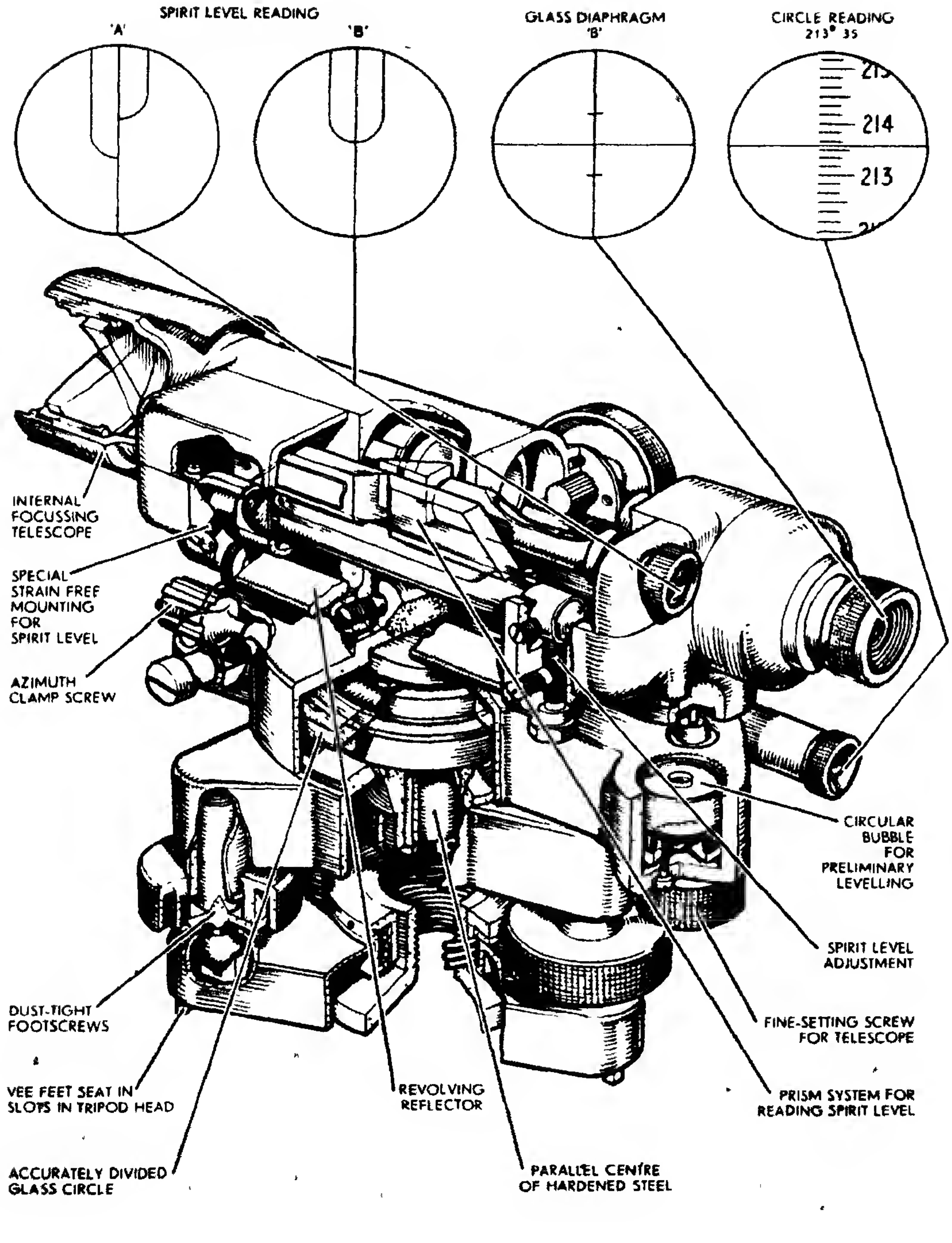


FIG. 2.—THE SURVEYOR'S LEVEL OF 1946

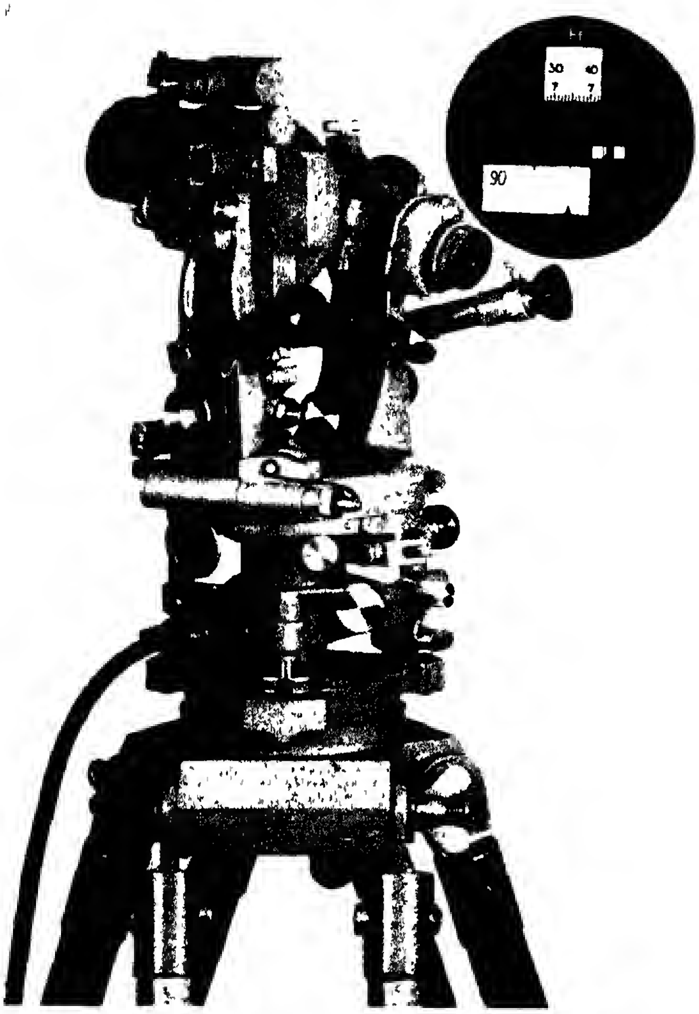


FIG. 3.—THE TAVISTOCK THEODOLITE
(Inset) Reading 90 deg. 40 min. 0 secs. + 0 deg. 7 min. 35 secs.
(Cooke, Troughton and Simms, Ltd.)

level to the more elaborate arrangement of prisms and lenses required on the most precise theodolite. In the latter case, a separate optical system for each circle provides the observer with the mean of two simultaneous readings at diametrically opposite points.

Although details of design in this two-side reading system, and the actual methods of engraving the circles differ with each manufacturer, the principle is the same. The optical system images the graduations on one point on the circle and this image is superimposed on the graduations at the diametrically opposite point, so that both sets of graduations are observed in highly magnified form in the eyepiece, and can be set for coincidence by moving the image of the first set in relation to the second. The displacement of the image is brought about by rocking a block of plain glass in the path of light. The tilting of the glass is controlled by a micrometer head and the amount by which the image has been displaced is measured in minutes and seconds on the micrometer scale, shown as a separate illuminated scale in the field of view.

Some of the optical theodolites incorporate an optical plummet in the body, a small telescope with screw-focusing eyepiece in convenient observing position, sighting downwards through a hole in the vertical axis. The use of this plummet for accurate centering will be appreciated, especially in a wind.

PRISM SYSTEM FOR READING

Another, but rather less recent, development is the introduction of a prism system for reading the alidade level by the coincidence method (Fig. 2), whereby the two ends of the air bubble are imaged together by prisms and viewed in an eyepiece. The exact horizontal setting is registered when the two images coincide, then as the level is tilted they move in opposite directions. The sensitivity of setting achieved by this method, which shows twice the actual movement of the bubble, is much greater than can be obtained by direct observation.

The advantages of the new optical instruments are undeniable. Not only are they capable of a degree of precision higher than that of vernier models, but reading to fine limits is accomplished with less eyestrain, thereby lessening fatigue on lengthy surveys. To-day, British manufacturers are producing the finest instruments in the world and one or two typical products are illustrated in these notes.

THEODOLITES

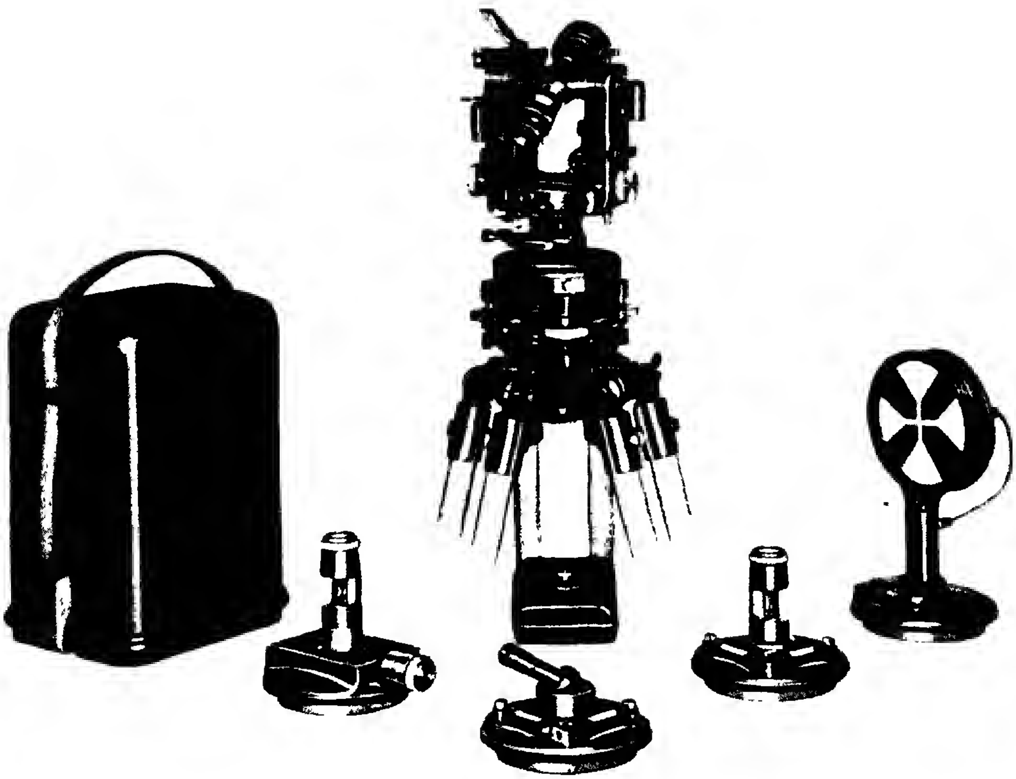
A suitable theodolite for general survey practice up to and including secondary triangulations is one illustrated in Fig. 3, incorporating the two-side circle reading system, reading direct to one second on both circles. In the field of view of the reading microscope are two illuminated windows showing the circle scale and the micrometer or

fine-reading scale, and a smaller window in which the graduations from both sides of the circle are set for coincidence by turning the micrometer milled head In the field of view illustrated, the graduation lines are shown in coincidence, equidistant on either side of the centre reference mark; the value shown against the index on the fine-reading scale is then added to the reading on the main scale Telescope and circle reading eyepieces, and the prism reader for the alidade level, are arranged to allow all observations to be taken from one position

If traversing is to be accomplished to the degree of accuracy achieved by the theodolite itself, equipment designed for the three-tripod system of surveying should be used (see Fig 4) Three tripods are equipped with centering movement on the head and a small circular level for preliminary setting up There is a further centering movement above the footscrews on the interchangeable levelling bases These have a large-diameter socket with three-point location for the instrument controlled by a single clamp screw, so that interchanging theodolite with index and measuring heads, targets or optical plumbing unit is a simple operation which can be carried out without disturbing the base after it is levelled

The small theodolite for general purpose surveying, where reading to very fine limits is unnecessary, is an exceptionally compact and easily handled instrument On one model of this type illustrated in Fig 5, separate optical systems for reading the horizontal and vertical circles are brought together in a single screw-focusing eyepiece and the reading is extremely simple The nearest 20-minute division on the main scale is brought exactly between a pair of fine index lines by rotation of the micrometer head, and the residual minutes and seconds read off on the micrometer scale Reading is direct to 20 seconds with easy estimation to 5 seconds

The new *Surveyor's Level* is also equipped with glass circle and optical system, reading directly to 10 minutes and estimating to 2 minutes Circles are sub-divided to 10 minute divisions or, alternatively, sub-divided to degrees and read against a graticule micrometer having 10 minute divisions. A prism system is provided for reading



(E R. Watts and Son, Ltd)

Fig. 4 —The "Traverse Outfit"

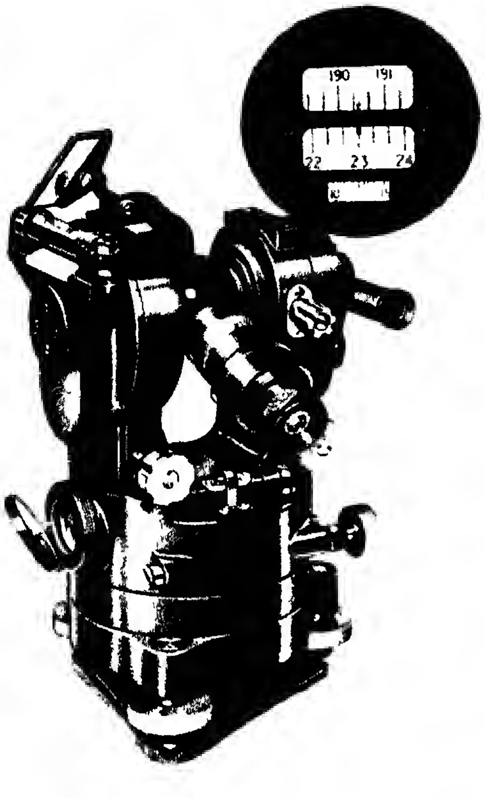


Fig 5.—The Watts's "Microptic" Theodolite No 0
(Inset) Horizontal reading 23 deg + 12 min 30 secs

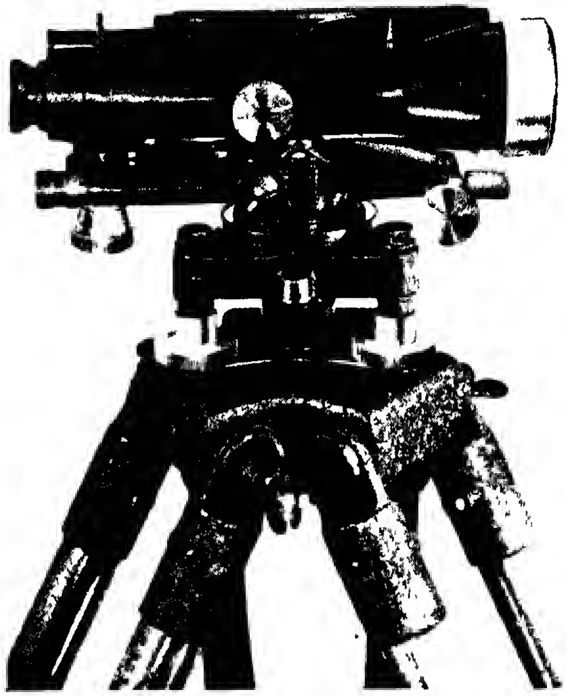


Fig. 6.—Cooke's Level S 300

the main spirit level and final levelling is made by a single fine-setting screw As with theodolites, a small circular level is fitted for preliminary levelling.

Considerable work has been done in recent years towards the perfection of the lens system in the telescope Much finer results are being obtained with new, short telescopes with larger aperture, and, at the same time, their reduced overall length permits the use of shorter standards. As a result, the total weight is reduced to a minimum consistent with stability, and a good proportion of that is concentrated in base and centre where it is most required

Among many improvements on the mechanical side, newly-designed base plates ensure an equal distribution of pressure and eliminate "shake", while short, sturdy footscrews are completely enclosed against dust and have easy adjustment for wear

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Section Two

SOIL STABILIZATION

PRINCIPLES OF SOIL STABILIZATION

By W P ROBINSON, C B E , B Sc , M Inst C E

DEFINITIONS of technical terms used in this branch of Highway Engineering are

Soil - A mixture of particles varying in size derived from the natural disintegration of rock, which may range from gravel to fine clay

Stabilization —The treatment and compaction of a soil in such a manner that it will remain in its initial compacted state without change in shape or volume when subjected to stresses and to the action of the weather and sub-soil water

Cohesion —The property of resisting the pulling apart of the particles

Density - The dry density of a soil is the weight of solid mineral matter per cubic foot of material It is determined from the bulk density of the soil by deducting the weight of moisture present

Gradation — The percentage of particles of varying sizes present in the soil

Liquid Limit —The moisture content at which the soil will just begin to flow when a standard specimen is lightly jarred in a specified manner It indicates the minimum moisture content which will bring the soil to the liquid state

Plastic Limit —The moisture content at which the soil crumbles when rolled into threads ⅛ in in diameter

Moisture Content —The percentage by weight of the amount of water present in a given volume of soil, stated as a percentage of either the dry or wet material

Optimum Moisture Content - -The moisture content at which the specified amount of compaction in a standard test will produce the maximum dry density

Mechanical Analysis —The determination of the grain size distribution of the particles

NATURE AND PROPERTIES OF SOIL

The nature of a soil is mainly determined by its mechanical analysis. Coarse particles have little cohesion and their stability depends on internal friction between the particles, which friction becomes smaller as the particles become finer Cohesion increases with fineness and decreases with increasing moisture content

The finest particles are usually clay particles. Soil contains (*a*) air, (*b*) water, (*c*) organic matter and (*d*) mineral particles The amount of air present is not important for road construction work; the amount of water present is very important as it affects bulk density, plasticity, resistance to deformation, compaction and crushing strength The presence of organic matter may be injurious to construction work by loss affecting density and by chemical action on the binder used for stabilizing the mineral particles The mineral particles possess varying properties according to the nature of the rock from which they have been formed For stabilization an important property is gradation, which is determined by mechanical analysis or grain size distribution of the particles Soils may be classified according to grain size into the groups given in Table I

TABLE I

Fraction	*Particle size in mm*	
	International System	*U S Bureau of Soils system*
Gravel	> 2.0	> 2.0
Coarse sand	2.0 → 0.2	2.0 → 0.25
Fine sand	0.2 → 0.02	0.25 → 0.05
Silt	0.02 → 0.002	0.05 → 0.005
Clay	< 0.002	< 0.005
Colloids		< 0.001

In general terms the heavier the soil the finer is the grain size The liquid and plastic limits are some indication of the type to which a cohesive soil belongs The plasticity increases with an increase in clay content The compacted density of a soil at optimum moisture content is related to its nature and the classification given in Table II has been suggested by K B. Woods.

TABLE II

Utility	*Maximum Dry density by Proctor test in lb. per cu ft*
Very poor	70 — 100
Poor	100 — 110
Fair	110 — 120
Good	120 — 130
Excellent	> 130

The nature and properties of soil have an important bearing on the efficiency of road construction and maintenance and on the design of road pavements. As the bearing resistance under load and deformation of the soil by loading and weather may vary, it is recognized that the road pavement, its foundation and the soil beneath, should be designed as a single structural unit. In road construction practice, the number of layers and the thickness of each layer to be superimposed on the soil should depend on the characteristics of the soil as much as on the kind and volume of traffic. Portland cement concrete may resist a crushing stress of 10,000 lb. sq. in. while the underlying clay may resist a shearing stress of only 20 lb. sq. in.; it is therefore necessary to provide a sufficient thickness of concrete or to insert an intermediate layer of weaker material in order to spread the load on to the soil so that the bearing stress in the soil does not exceed that which it is capable of supporting.

In the construction of new roads involving the excavation of cuttings and formation of embankments, the nature and properties of the soil have an important bearing on the design and methods of construction, not only with regard to the design of the road pavement but also to the stability of the embankments and the slopes of the cuttings. In the maintenance of existing roads, the action of water and frost on the supporting soil often causes more damage to the surface paving than the traffic, which damage could have been prevented by stabilization of the soil. Road surfacings are frequently taken up by public utility companies to lay and repair underground cables, mains, pipes, etc., as a result of which the soil under the paving is disturbed and its properties detrimentally changed. It will therefore be appreciated that a knowledge of the nature and properties of soil and of methods of stabilization is necessary for the efficient design of earthworks, road pavements, road drainage, road construction, maintenance and repair.

USES

Stabilized soil may be adopted for the following purposes.

1. *For filling in pipe trenches under road pavements* with the object of preventing settlement in the filling material and avoiding the consequent damage to the pavement. Where the soil excavated in a trench is suitable in nature and grading, it may be mixed in a mechanical mixer with an appropriate quantity of binder, the trench refilled and if the soil is thoroughly compacted to maximum density, no settlement will take place. The extra cost of mixing the soil with a binder is justified by the saving in cost of making good damage caused by settlement to the road pavement.
2. *For filling in behind retaining walls, over arches and culverts and in confined spaces where it is not practicable to employ rollers for compaction.* In the case of reinforced concrete retaining walls with counterforts it is almost impossible to rely upon obtaining maximum density in the filling material unless such material is mechanically compacted at its optimum moisture content to maximum density.
3. *As a sub-base of appropriate thickness under road surfacings, footways and cycle tracks, floors to buildings, school playgrounds, car parks, farmyards and aerodrome runways.* In those districts where rock suitable for road stone is not available or its cost is excessive, the use of stabilized soil offers an efficient and economical substitute by the use of local soils, such as sand, clay sand, and mixtures of gravel, sand and clay.

   For some years the practice has been adopted in Surrey of laying a sub-base of stabilized soil, (usually 4 in. thickness of sandy clay), on which to lay the surfacing of cement concrete or bituminous macadam. By so doing the thickness and cost of the surfacings have been reduced, the underlying soil has been water-proofed and the cost of maintenance has been minimized. For the paving of playgrounds, car parks, footways and cycle tracks and the carriageways of light traffic roads a layer from 3 in. to 4 in. thick of stabilized soil on a well-drained formation will often be adequate to meet all requirements. The surface of the stabilized soil should be protected from damage by abrasion by the application of a thin surfacing or dressing of tar, bitumen, tarmacadam or concrete.
4. *As a surfacing for low-cost roads subject to light traffic.* During the war, the repair or reconstruction was undertaken of several occupation roads which had been damaged by vehicular traffic because of insufficient strength and stability of the clay sub-soil, which was softened by infiltration of water necessitating frequent addition of stone for repairing the wheel ruts. The laying of a surfacing from 4 in. to 6 in. thick of stabilized

sandy clay, using Portland cement as a binder waterproofed the sub-soil and increased the load bearing power of the clay. The surface was dressed with hot tar and ½ in gravel rolled in by tandem roller

5 *In the formation of embankments and filling in of pits* The usual procedure hitherto has been to tip the filling material in thin layers each compacted by rolling and making some allowance for the anticipated settlement which would occur if the filling should not be compacted to maximum density or be affected by the weather during construction The employment of stabilization by mechanical means during the placing of the layers and the placing of a waterproof surface layer will ensure that no settlement will occur, thus speeding up the work of laying the running surface and avoiding subsequent damage thereto The use of a stabilized sub-base on embankments as a foundation for the final surfacing provides a convenient track on which to transport the materials to be used in the final surfacing and avoids much damage caused to the formation by such transport

Carriageway with Sub-base of Stabilized Soil

A new road with one carriageway 30 ft wide and one footway 6 ft wide has been constructed in Surrey, in which the carriageway was provided with a Portland cement concrete surfacing 3 in thick laid on a stabilized soil sub-base 8 in thick, and the footway was formed with a surfacing of stabilized soil 3 in. thick surface-dressed with tar and chippings The carriageway surfacing consisted of 5 2½ 1 (by weight) unreinforced and vibrated concrete laid immediately after compaction of the soil sub-base, which contained 6 per cent by weight of Portland cement as a binder Although this road has been subject to continuous heavy lorry traffic from an adjacent sand-pit and a military depot, its condition after three years' use is satisfactory

About 9000 sq yds of yard were paved with a 4 in. thick layer of stabilized soil surfaced with an 8 in. layer of 4 2 1 (by weight) gravel concrete unreinforced, for use by the heaviest type of military trackless vehicles The soil for stabilization was a mixture of stone, clay and sand and was mixed with 6 per cent by weight of Portland cement in vertical drum batch-type concrete mixers, the mixture being compacted by a concrete vibrating machine Waterproof paper was then laid on the soil sub-base to receive the concrete which was also compacted by the same machine. Plain butt joints at 90 ft intervals filled with a ¾ in jointing material were provided to allow for expansion and contraction After two years' use no damage has been done to the surface and no cracking has occurred in the concrete

MATERIALS AND METHODS

Some soils may be suitable for stabilization by mechanical compaction without the addition of any binder Gravels containing a suitable proportion of sand and clay or having the latter added thereto may be used provided the necessary control is exercised over the grading and the moisture content, and compaction to maximum density is effected This method was partly adopted by the Air Ministry when constructing the concrete runways at the new London Airport Compaction was effected by the passage of tractor-drawn sheepsfoot rollers and large diameter rubber-tyred wheels suitably loaded

The highway engineer will be called upon to determine whether a particular soil may be suitable for stabilization In order to do this, soil surveys and laboratory tests are necessary (See page 65)

Methods of stabilization include

Mechanical Compaction

This method is adopted when the soil has natural stability or in cases where stability may be obtained by drainage and mixing with suitable proportions of other soils but where the addition of any stabilizing agent such as cement, tar or bitumen is not required

Addition of a Stabilizing Agent

The stabilizing agent, may be a liquid or a powder, including bitumen, tar, emulsions of both, road oil (S S O), calcium chloride, sodium chloride, Portland cement, resin and sodium rosinate

METHODS OF CONSTRUCTION

The process of stabilizing the soil may be divided into three main headings (*a*) mixing, (*b*) spreading and levelling and (*c*) compaction and finishing

Mixing

This method may be sub-divided under three headings: (i) by means of stationary plant, (ii) by travelling plant and (iii) by mix-in-place.

Fig. 1. Stationary Mixing Plant

The stationary plant method is preferable for highway work in Great Britain, because it is easily and conveniently adapted for comparatively small areas and is likely to produce the most uniform results with the minimum of interference by the varying climatic conditions. Although it involves the transport of the soil and its stabilizing agent to the mixing plant and the transport of the mixed materials to the site of the construction work, full control can be exercised over the grading of the soil, the moisture content, the proportion by weight of binder and soil, and the efficiency of the mix, with the minimum of supervision. Stationary mixers of three types may be used, i.e. the vertical non-tilting drum type of portable concrete mixer, the double-paddle type of tarmac mixer, and the horizontal pan-type of mortar mixer. The mixer is usually erected in the pit or on the site where suitable soil is found, the soil being excavated mechanically and dumped direct into the weighing hopper adjacent to the mixer. (See Fig. 1.) The mixed soil is discharged direct from the mixer into motor lorries fitted with tipping bodies, for transport to the site of the construction work.

The method of mixing in travelling plant has been extensively used in the U.S.A. The travelling plant in its essential features is similar to the continuous mixing stationary plant but is propelled under its own power. A typical example is the Barber-Greene machine, which has been used in Great Britain during the war. It consists of a mobile bucket elevator which picks up the soil from a previously formed windrow and deposits it into a mixer hopper. The mixer is of the double-paddle type operating continuously, the soil and binder being measured by volume. The machine discharges the mixed soil onto the formation in the form of a windrow ready for spreading by means of blade graders. Mixing by travelling plant is preferable to mix-in-place because should bad weather interfere with the work, the mixing can be stopped, whereas in the mix-in-place method large areas of mixed material are exposed to changes in the weather after being spread and until compaction has been completed.

The third method, "mix-in-place", obviates the need for excavating, transporting and windrowing. The soil on the site is mixed by first ploughing the ground to the required depth, using a three- or four-furrow plough drawn by tractor, the ploughing is followed by harrowing and cultivating until

the soil has been pulverized to a fine tilth. The soil is then ready to receive the binding agent. If Portland cement is the binder the usual practice is to place bags of cement over the prepared soil at predetermined intervals so that the cement in each bag covers when spread a specified area at a uniform rate. Mechanical spreading of the cement is to be preferred where large areas are being covered. If a liquid stabilizing agent is being used, it may be spread by means of self-propelled tank wagons delivering the liquid through a spray pipe or series of jets under pressure.

SPREADING AND LEVELLING

When the soil has been mixed in a stationary plant and transported by motor lorry, it is usually tipped onto the formation and spread by a blade-grader or, where the area is extensive, tipped into a box-spreader. For comparatively small areas the mixed material may be spread manually or by a suitably-sized bull-dozer or angle-dozer, pegs or screeds having been previously set as a guide to the finished levels required. The use of box-spreaders will expedite the rate of spread and give a more uniform result than is possible by manual spreading.

When the material has been mixed in a travelling mixer on the site of the work, the windrow of mixed material formed by the mixer is spread out over a predetermined width, using a blade-grader working firstly from one side of the windrow. After spreading with the blade-grader further cultivation with a cultivator and levelling with the grader may be required to ensure uniformity in the layer thickness, which is important to ensure uniform compaction and density.

With the mix-in-place method, no spreading of the soil is required but water may have to be added to obtain the correct moisture content, this usually being effected by tank wagons fitted with spray pipes and hauled by tractors. The binder is spread as stated in the last paragraph. Further mixing after the addition of the binder is carried out by means of cultivators, disc harrows, and chain harrows in order to ensure distribution of the binder and to break up any lumps that may have formed. Final levelling prior to starting compaction would be effected by blade-graders.

COMPACTION AND FINISHING

Whatever type of mixing, spreading and levelling is employed, the compaction must be thorough and complete to ensure success. The type of machine required for compaction will depend on the area of the work. For extensive areas, sheepsfoot and rubber-tyred rollers drawn by tractors, preferably tyred with rubber, are used, final rolling being by 6 to 8 ton tandem rollers. The sheepsfoot and rubber-tyred rollers compact the mixture but the surface will require regrading or levelling before final rolling with the tandem roller. For relatively small areas, it has been found that pneumatic punners of the type illustrated in Fig. 2 are quite effective for compaction.

The screeds shown in the illustration are 3 in thick, the mixed soil being spread to a loose thickness of 5 to 6 in for compaction to a finished thickness of 3 in.

The rate at which compaction is effected is about 1 foot lineal for a width of 10 ft, i.e. 10 sq ft per minute, or 66 sq yds per hour. The machine illustrated in Fig. 4 has three pneumatic rammers spring-mounted on a frame fitted

FIG. 2.—PNEUMATIC PUNNER

FIG. 3.—1 IN. CONCRETE FLOOR WITH 5 IN STABILIZED SOIL SUB-BASE

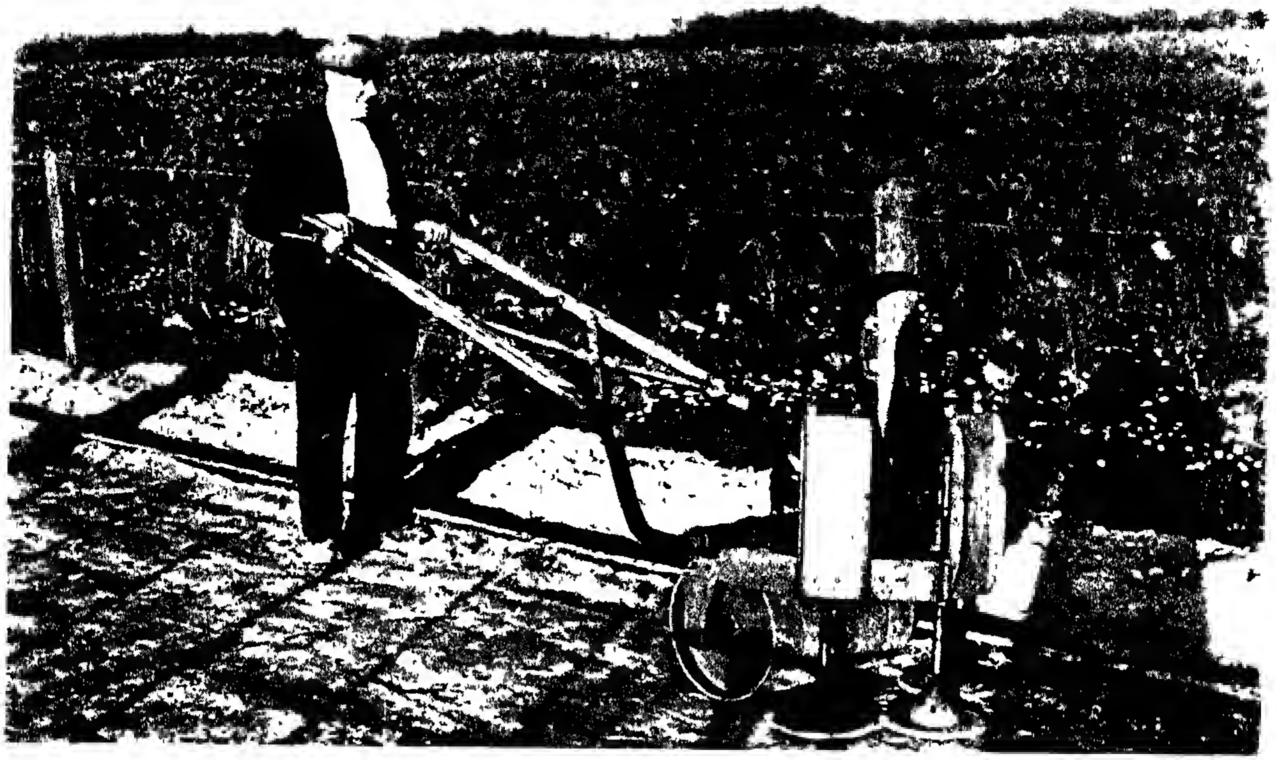


FIG. 4 SOIL COMPACTING MACHINE

(Broom and Wade Ltd.)

with a roller, handles and air-hose and was made especially for soil compaction. The use of these pneumatic punners tends to leave an uneven surface to the compacted soil, consequently if a true riding surface is required some means of trueing must be adopted. Use may be made of a steel-cutting blade which is worked by two men, the blade being guided by the screeds and worked with a transverse as well as a longitudinal motion, thus cutting off the surplus material which is removed and respread. Alternatively the rough surface may be raked over and relevelled prior to rolling with a tandem roller.

Fig. 5 illustrates a new road 9 ft. wide, constructed of a 6-in. thick layer of cement stabilized soil compacted with a single pneumatic punner and surface-dressed with tar and gravel chippings. Fig. 6 shows a yard for cattle, paved with cement-stabilized soil 3 in. thick, the surface having been cured and sealed with bitumen emulsion.

CHECKING LEVELS

During the process of spreading, compacting and finishing, frequent tests should be made to check the levels, the moisture content, the rate of distribution of the binder and the density of the compacted mixture. When cement has been used as the binder, the finished surface should be covered with waterproof paper, tarpaulins or other suitable material which will retain the moisture in the soil for at least seven days. A seal coat should be applied to the finished surface to prevent changes in moisture content. When cement has been used as the binder the seal coat obviates the use of other curing material if applied immediately after completion of the final rolling.

The type of wearing surface required will depend on the kind and density of traffic. It may vary from a surface dressing of tar or bitumen spray covered with stone chippings, to a layer of tarmac or concrete. Fig. 3 illustrates a floor constructed with a 1 in. thick concrete surface laid on and united with a 5 in. thick cement stabilized soil sub-base.

In the application of a bituminous surface spraying, the surface of the stabilized layer should be swept to remove loose dust, and every possible means employed to ensure adhesion of the tar or bitumen, which should preferably be used at the highest temperature possible without injury to it

Fig. 5.—9 ft. Road

Fig. 6.—Yard for Cattle

It may not be necessary to apply a tack-coat to cement stabilized soil bases when superimposing a surfacing of tarmacadam If the sub-base is screeded to correct levels and cambers and the spreading and compaction of the tarmacadam surfacing are uniform in thickness and density the riding surface should be of a high standard

SURVEY AND TESTS*

Before beginning to design any new highway a soil survey should be made along the proposed line of route to determine the nature and depth of the various soils, whether any of them may be suitable for stabilization, their load-bearing capacity and drainage conditions Borings with a 4 in to 5 in soil auger should be taken at frequent intervals, the extracted soil being placed in air-tight tins and sent to the laboratory for examination and identification The chief tests to be made in the laboratory are to ascertain grading, liquid limit, plastic limit, and moisture content, for the purpose of classification and to determine whether the soil, either alone or in combination with added material and binder, may be suitable for filling, for support of the load to be imposed and for use in the construction of sub-bases and surfacings

Having determined by laboratory tests that a particular soil is suitable for stabilization with the addition for example, of a Portland cement binder, tests are required to determine *(a)* the presence of organic matter and salts which may be injurious to the cement, *(b)* the optimum moisture content, *(c)* the optimum water cement ratio, *(d)* the proportion of soil to binder, and *(e)* the compressive resistance of the compacted mixture The presence of organic matter may be ascertained by loss of weight after ignition The optimum moisture content and maximum density are ascertained by the Proctor apparatus The optimum water-cement ratio is determined by making a series of test cubes of different ratios and breaking them under compression at a specified age, say seven days The proportion of soil to binder is determined by making a series of test cubes of different proportions The compressive strengths of test cubes made of sandy clay with from 5 to 6 per cent cement binder have varied from 200 lb /sq in to 1000 lb /sq in at the age of seven days

The standard compaction test apparatus consists of a cylindrical metal mould 4 in diameter and 4½ in high standing on a detachable metal base, a metal tamper 2 in diameter and weighing 5 5 lb falling in a guide tube through a height of 12 in The soil is compacted in the mould in three equal layers, each layer receiving twenty-five blows Having decided upon the moisture content and the proportion of cement as binder, the materials should be batched by weight of dry materials and mixed in a mechanical mixer, frequent tests being made to ascertain the moisture content in the soil by means of the pycnometer test † During the process of compacting the soil, the degree of compaction should be frequently checked by measuring the depth of penetration produced by one blow of the 5 5 lb rammer previously mentioned

STANDARD METHODS OF TESTING

There is an urgent need for the publication of British Standard methods of testing for. *(a)* preparation of samples, *(b)* determination of moisture content, *(c)* liquid limit, *(d)* plastic limit, *(e)* density, *(f)* particle size distribution and *(g)* compaction The British Standards Institution has agreed to publish such standard specifications, which are in course of preparation

* See also article on Preliminary Surveys and Site Investigation, page 26

† See "General Survey of Materials," page 173

SOIL STABILIZATION WITH EMULSIFIED BITUMEN

By A. E. LAWRENCE, B Sc., A R I C.

The purpose of soil stabilization is to render a clay bearing soil capable of carrying a load under adverse moisture conditions When dry, clay has a very high load-bearing capacity and compressive strength In fact, it has been stated that the compressive strength of dry clay is nineteen times as great as that of cement * Unfortunately, clay loses its strength very rapidly as the moisture content increases and soon becomes a sticky mass with a low load-bearing capacity—hence the need for stabilization Fig 1 shows the compressive strength of a clay-bearing soil at different moisture contents

METHOD OF STABILIZATION

It is convenient to divide soil stabilization into two categories

1 Stabilization without waterproofing
2 Stabilization with waterproofing.

The first type has been defined† as "the process of giving natural soils enough abrasive resistance and shear strength to accommodate traffic or loads under prevalent weather conditions without detrimental deformation."

In this case, the required stability is imparted to the soil by regrading, i e , by the addition of such material as will enable the soil to conform to the following specification·

Clay . .	5–10%
Silt . .	10-20%
Fine Sand .	20–50%
Coarse Sand	35-50%

Such a soil may be mixed with up to an equal part of stone. Results obtained by this method of stabilization are much improved by adding such chemicals as calcium chloride or salt to keep the soil at its optimum moisture content. It must be pointed out, however, that the results obtained are not as positive or permanent as those obtained by the addition of a waterproofing agent

USE OF BITUMEN EMULSION

The forms in which a waterproofing agent (or, more correctly, an agent which renders the soil resistant to water) may be added are many and various It is obvious, however, that a very convenient form is emulsified bitumen, in which water is used as the carrier. Many thousands of square yards of stabilized soil have been constructed in this country using this process, with somewhat varying results The reason for the variability of the results obtained lies in the fact that in order to possess good water resistance and strength, it is essential for a bitumen emulsion stabilized soil to dry to a moisture content of under 5 per cent. Such a moisture content proved difficult to attain in some cases in this country, with the result that the stabilized soil never developed its maximum resistance to water and tended to soften under adverse weather conditions. In other cases, where adequate drying had been obtained, the results were quite satisfactory. Fig 2 shows a portion of a school playground stabilized with bitumen emulsion in 1939, which was surface dressed and has not been touched since.

In view of the uncertainty of the soils attaining a moisture content of under 5 per cent in this country, investigations were carried out to see how stabilized soil could be made to carry the load at higher moisture contents. As a result of these investigations, the

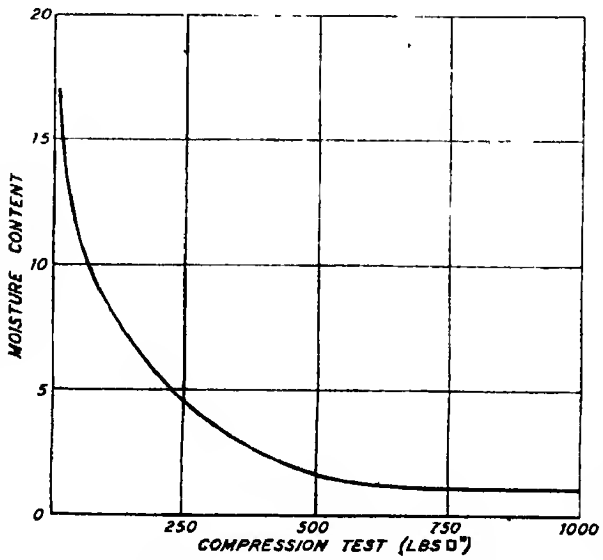


Fig. 1.—Compressive Strength of a Clay-bearing Soil at Different Moisture Contents

* Highway Research Board, U S.A *Progress Report of Project Committee on Stabilized Soil Road Surfaces*, 1935

† Hogentogler, *Engineering Properties of Soil*, page 262

"Lomix" Emulsion/Cement process was evolved (B P. 557, 426) The addition of the cement enabled the stabilized soil to carry the load and resist water at moisture contents of 10 per cent and higher. By using a combination of "Lomix" emulsion and cement, a mixture is obtained which combines the rapidity of set of a soil/cement mix with the plasticity of a soil/"Lomix" emulsion mix, together with adequate resistance to immersion in water

GRADING

In order to obtain the best results, it is desirable for the soil to conform to the following grading limits

Passing	1 in	90-100%
Passing	¾ in	55 85%
Passing	8 mesh	50-80%
Passing	200 mesh	20-40%

At least 10 per cent of the portion passing the 8 mesh sieve to be finer than 0 005 mm

It has been found that a soil falling within the above limits will in general be stabilized satisfactorily with 5-7 5 per cent of "Lomix" emulsion and 5 per cent of cement It is necessary, however, to carry out laboratory tests to determine the correct quantity of stabilizer for any particular soil

LABORATORY TESTS

It may be of interest to indicate briefly the tests carried out to determine whether a soil is suitable for stabilization by the "Lomix"/cement process and, if so, the percentage of stabilizer to be used

It is obvious that the most important is the *Size Analysis Test* For this purpose, the dried soil is carefully sieved through the 1 in, ¾ in, 8, 36 and 200 mesh sieves. It is washed through the 200 mesh sieve until the issuing water is clear For the determination of the percentage passing 0 005 mm and 0 001 mm, a method based on the rate of settling of deflocculated soil is used

It is advantageous to plot a grading graph, the percentage of each size being plotted on an arithmetic scale and the actual particle size on a logarithmic scale

Identification Tests are also carried out on the soil. These include the liquid limit, plastic limit and plasticity index†, all of which are determined by standard methods. In addition, an estimate is made of the organic content of the soil, either by determining the loss on ignition or by any other recognized method.

† See article on "Preliminary Surveys and Site Investigation," page 30.

In order to determine whether any particular soil may be stabilized satisfactorily by the "Lomix"/cement process, test cylinders (4 in. high, 2 in. diameter) are prepared, containing varying amounts of stabilizers and subjected to compression and water immersion tests One point to notice in connection with these tests is that the cylinders get only 24 hours drying on the bench before being tested This means that the majority still contain at least 10 per cent water before being tested. Typical tests figures are

Moisture content when tested	10 5%
Compression test	230 lb. per sq in
Water absorption (7 days immersion)	2 6%
Compression test after water absorption	140 lb per sq. in.

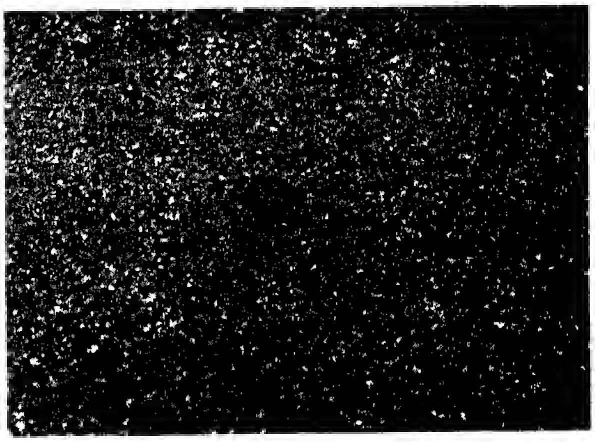


FIG. 2 SCHOOL PLAYGROUND STABILIZED WITH BITUMEN EMULSION

Consideration of these figures shows that an unsupported cylinder of soil stabilized by the "Lomix"/cement process is capable of carrying a load of 9 tons per square foot after being completely immersed in water for one week It has been found that prolonging the period of immersion to one month does not materially affect the strength obtained In fact, experience has shown that if the compression test is satisfactory after the sample has been immersed for 24 hours, than it will in general also be satisfactory after an indefinite period of immersion.

METHODS OF CONSTRUCTION

The method adopted for field work is governed to a very large extent by the size of the area in

FIG. 3 —CONCRETE MIXING PROCESS
(*Top*) Adding emulsion to mix (*Second picture*) Tipping mixed soil from mixer (*Third picture*) Spreading soil by rake. (*Bottom picture*) Rolling with power roller 24 hours after laying.

question For small areas, say up to 2,000 sq yds , or for footpaths, etc , a concrete mixer may be used. For larger areas, say up to 20,000 sq. yds., farm machinery is employed, whereas for very large areas some type of travelling road mixer is advisable

USING A CONCRETE MIXER

The site is prepared to the desired levels and falls and the top 4 in. of the soil removed in readiness for mixing (The thickness removed depends, of course, on the depth of stabilized material required 4 in has been quoted as being a typical thickness) The base should then be consolidated by rolling The excavated soil is put in a concrete mixer and moistened with water if necessary The emulsion is then added and mixing continued until the emulsion is well dispersed through the soil More water may be added if necessary to ensure a homogeneous mix, but this additional water must be kept to a minimum Finally, the cement is added and thoroughly mixed

By keeping the amount of water added to the minimum consistent with efficient mixing, it is often possible to lay the mixture immediately in the same way as a cold carpeting material, i e , by means of rakes This is especially so for soils of low clay content For soils of high clay content, or where it is necessary to produce a "wet" mix, the mixture may be laid immediately in the same way as concrete, or stockpiled and spread with rakes the following day

Whichever method of laying is adopted, preliminary rolling should be carried out soon after laying, generally with a hand roller up to 10 cwt in weight After 24 hours it is normally possible to roll with a 50-cwt power roller, but precisely when this can be done depends very largely on the weather The importance of adequate consolidation cannot be over emphasized if it is desired to obtain a smooth, well-bonded surface.

This type of construction is illustrated in Fig 3

USING FARM MACHINERY

The following equipment is usually adequate:

Tractor (Fordson or Caterpillar type)
Blade Grader
Ripper and spring tooth harrows
Sheep's foot tamping roller.
Road roller (at least 50-cwt.).
Spray tank.

The site, as before, is first graded to correct levels and falls and loosened to a depth of 5 to 5½ in. with the ripper or harrows (assuming it is desired

to finish with a 4 in consolidated thickness of stabilized soil) Water is then sprayed on, if necessary, until the soil reaches a consistency approximating to the Plastic Limit. The emulsion, preferably previously diluted with water, is next sprayed on the soil from a pressure tank distributor and mixed by means of the harrows It is necessary to make several applications (usually 3 or 4) of the emulsion until the total quantity required per square yard has been applied Each application is mixed with the soil by means of the harrows

The area is allowed to dry for 24 hours and the cement spread at the specified rate (usually 6 sq yds per cwt) and mixing carried out with the harrows

The stabilized soil is then allowed to dry to a moisture content suitable for compaction with the tamping roller It is often possible to use this roller immediately after the cement has been mixed in, but this depends upon the prevailing weather Rolling with the tamping roller is continued until the feet of the roller ride well up on the surface Marks left by this roller are removed by means of an ordinary road roller

When the final consolidation has been accomplished, the stabilized soil is allowed to dry to a suitable moisture content for application of a wearing surface During the drying period it is quite permissible for the area to be used by traffic

TREATMENT OF LARGE AREAS

It is possible to carry out the stabilization of very large areas by the method outlined above, but it is usually more economic to carry out the mixing by means of a travelling road mixer, such as the Woods or Barber-Greene machines The essential constructional details are the same, except that mixing is carried out by the machine

THICKNESS REQUIRED

It must first be pointed out that soil stabilization by the "Lomix"/cement process has, in general, only a limited resistance to abrasion and it is therefore necessary to provide some form of wearing surface It is, however, very suitable as a base for roads, footpaths, school playgrounds, car parks, aerodrome runways, etc The thickness required depends, of course, on the load the stabilized soil is required to carry. For footpath work, if laid on a sound sub-base, a consolidated thickness of 1 to 1½ in. is adequate. If the base is not sound, e g , if laid directly on unstabilized soil, a consolidated thickness of 2½ to 3 in. is recommended

A 4 in consolidated thickness should be used for car parks, runways (light aircraft), secondary roads, and as a base under concrete on main roads, housing estates, etc

SURFACE TREATMENT

The surface treatment required varies with the amount of traffic the area or road carries For footpaths or lightly trafficked roads, a spray with quick-breaking bitumen emulsion at 4 sq yds per gallon, followed by chipping up with ⅜ to ¼ in aggregate is adequate For a road carrying moderate traffic, it is necessary to give a double dressing with bitumen emulsion or to apply a carpet coat For main or trunk roads, concrete with or without a carpet coat should be used.

THE "RETREAD" PROCESS

Closely allied to bituminous soil stabilization is the "Retread" process for the treatment of road surfaces It was originally designed for the treatment of waterbound macadam, but has been found to be equally suitable for renovating tar or bitumen macadam and surface dressed roads In each case the method is the same, but the type and quantity of emulsion is varied to suit the grading of the aggregate it is required to treat

Briefly, the process consists of scarifying the road surface to the required depth (generally 3 in loose) This may often be done with a strong ripper towed by a tractor, but it is sometimes necessary to use the scarifier attached to a steam roller Any reshaping is now carried out, the road being prepared to the required cross section and falls by means of a blade grader This is followed by spreading any necessary admixture at the specified rate and mixing this with the road aggregate by means of spring tooth or spike harrows

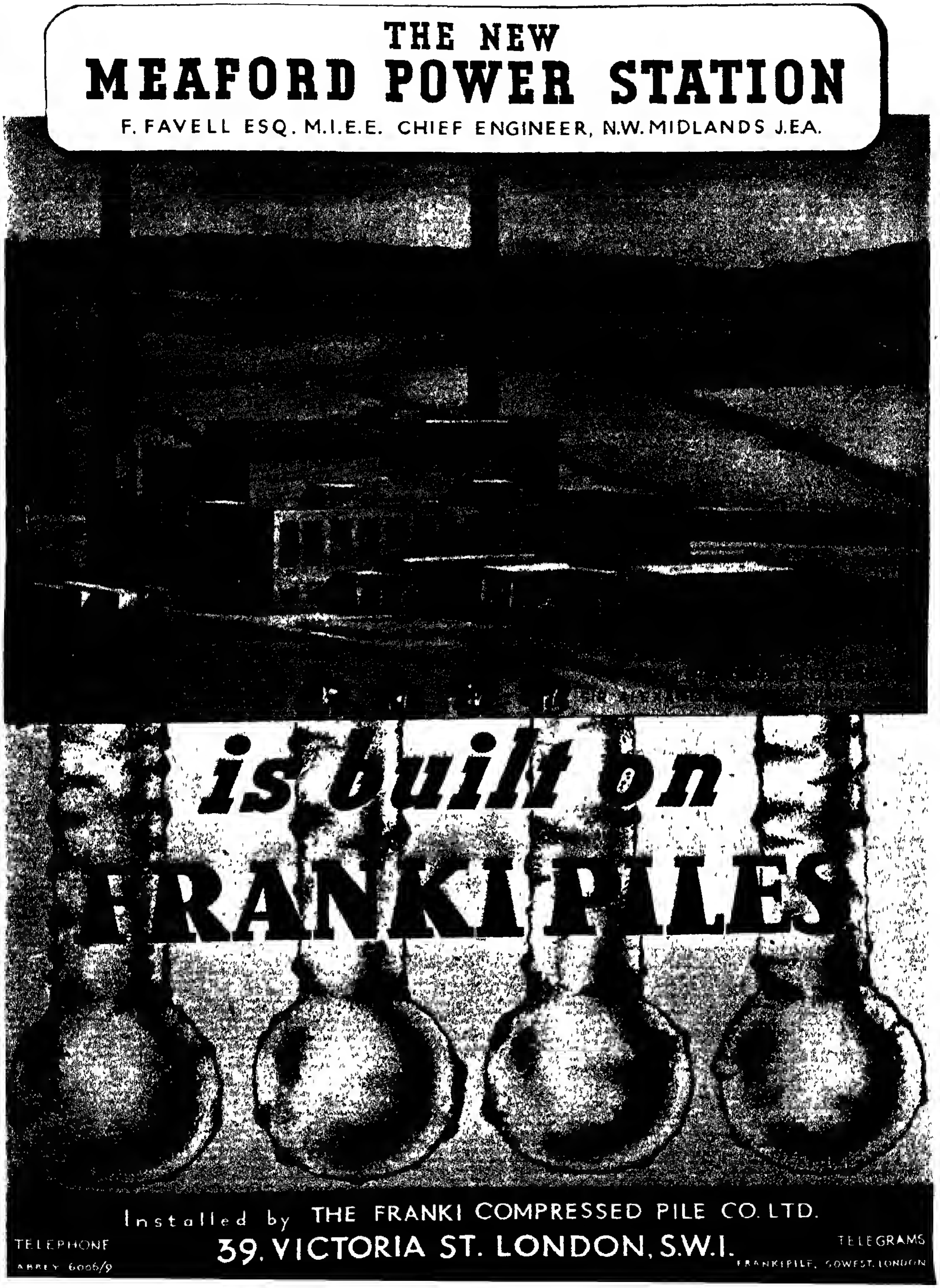
The specified quantity of emulsion (usually 1 to 1½ gallons per square yard for a 2 in. consolidated thickness) is now sprayed in three applications from a pressure distributor, each application being followed by mixing by means of the harrows If the specification requires cement to be added (normally only necessary if the aggregate contains an appreciable quantity finer than ⅛ in) this is spread and mixed immediately after completion of the emulsion mixing

The road is then consolidated with a 5- to 10-ton roller In normally fine weather conditions,

preliminary rolling may be carried out within half an hour of the time of application of the emulsion, followed by back-rolling 24 hours later.

As in the case of soil stabilization, some form of surface treatment is recommended if most lasting results are to be obtained For lightly trafficked roads, a single spray of quick break/bitumen and chipping up with ¼ or ⅜ in chippings is sufficient, but for heavy traffic a double dressing should be given.

SPECIALISTS IN SOIL STABILIZATION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Section Three

ROAD LAY-OUT

DESIGN AND LAY-OUT OF ROADS

By E C BOYCE, B.Sc, AMICE

In considering the subject of road design and lay-out, it is necessary first to mention the means which are available for identifying on a map the existing features and characteristics of the locality with which the engineer is concerned

SURVEYS AND PLANS

In Great Britain road engineers are fortunate in having at their disposal the ordnance survey, the sheets of which in normal times may be obtained for any part of the country to scales of 1 2500, 6 in to one mile and 1 in to one mile, there are also various other editions of smaller scales which may be used for key maps, and for certain parts of the country sheets to 1/500 scale may be available, particularly for towns and built-up areas The former scales, however, are those mainly used by highway engineers and serve most general purposes. Fig 1 shows some typical ordnance maps

Outside Great Britain survey maps may or may not be available, and in the latter case the engineer may be involved in the necessity for determining his meridian by astronomical survey and for fixing his own bench marks, which need not of course be necessarily related to sea level Location of highways through uncharted territory involves special problems which depend upon the nature of the terrain and which can best be appreciated by the study of an advanced text book on surveying In this country, however, ordnance survey sheets can normally be obtained through the local agent in the larger towns, but in most of the larger offices where plan reproduction machines are installed it is an advantage to obtain a licence from the Director General of Ordnance Survey to reproduce ordnance sheets on a royalty basis Full particulars of the regulations may be obtained on application to the Head Office of the Ordnance Survey Department. The reproduction of such sheets does not, however, preclude the desirability of holding a stock of most of the original sheets for the area with which the engineer is concerned, particularly the 1/2500 scale maps The 6 in. to one mile plans show contours in addition to the location of bench marks and spot levels, and are of a useful size for easy handling in the field as a basis for the preparation of a detailed survey.

The surveys and plans required for highway design will vary with the class of work with which the engineer is concerned, and may be broadly divided into three general categories

(*a*) Carriageway reconstruction on an existing road
(*b*) Widening and improvement of an existing road involving the acquisition of additional land
(*c*) Location and construction of new roads

In the case of (*c*) different considerations arise as to whether the road will be used for motor traffic only or for mixed traffic

Carriageway Reconstruction

It is, however, in connection with the rebuilding of the carriageway of an existing road that the 1/2500 ordnance sheet is so useful, it is seldom necessary to prepare a large scale survey for this class of work if the following procedure is adopted

The engineer should first examine the alignment of the road on the map on which the carriageway is usually shown Where the latter is tolerably straight no larger scale plan will be required, but where there are sharp curves showing radii of less than the minimum required to enable opposing streams of traffic to have an adequate view of one another, then the particular section should be earmarked for detailed survey The engineer should then inspect the road on the ground and record those places where the sight line is obscured by acute vertical curves The next stage is to prepare surveys of the acute bends earmarked for improvement to either 1/500 scale, or if they are in built-up areas to a scale of 20 ft to 1 in The preliminary inspection should also confirm the lengths where widening improvement is necessary, should record existing and new drainage required and particulars of the present construction and the location of services

The second stage is to prepare the levels; these should consist of a profile of the crown of the road, which should be chained and marked, every 25 ft. and every 300 ft point being indicated with a steel pin, the chainage in each case being painted alongside the chainage points Levels should then be taken at every 25 ft. on the crown of the road

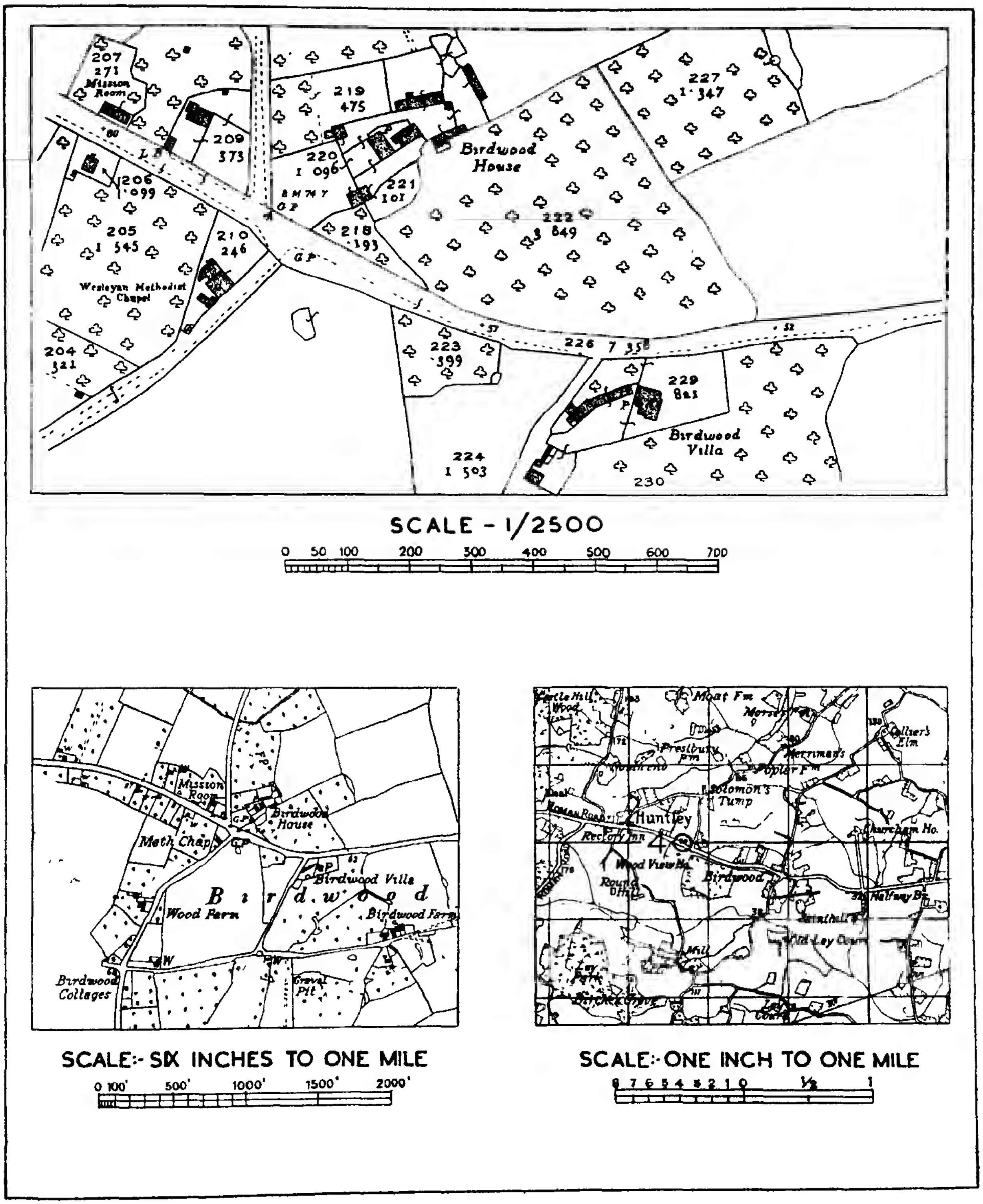


FIG. 1.—TYPICAL ORDNANCE SHEETS

(By Courtesy of the Director General of Ordnance Survey)

and channels, and cross sections should be taken at every 300 ft point or more often as dictated by the layout of the existing route At those points earmarked for improved vertical visibility, cross sections of the full width of the highway are required every 10 ft. or 25 ft and on those sections where the larger scale surveys are required, cross sections should be taken every 25 ft Where gradients are flat, channel levels should be taken, if necessary, more frequently than 25 ft apart For drainage purposes levels should be taken at inverts and soffits of all existing pipes and culverts and at outfall points

Fig. 2 —Reconstruction of London–South Wales Trunk Road in Gloucestershire Route A 40

Concurrently with the levelling a "running commentary" should be prepared of points arising during the course of the levelling and inspection, such as details of drainage run-offs, built-up frontages, threshold levels, entrances, conditions of verges, culverts requiring lengthening, bridge details, lengths where filling is required on super-elevated curves, and any other useful data upon which an economical and complete design will depend. Fig 3 shows a typical survey sheet with section and notes.

From the field work described it now becomes possible for the engineer to design his reconstruction. He will firstly require to define the standards to which he is to work The crossfall for normal camber should be 1 in 40 for an asphalt finish, 1 in 36 for $\frac{1}{2}$ to $\frac{3}{4}$ in gauge surfacing or 1 in 45 for concrete. He will need to decide the maximum super-elevation on the sharpest bends and relate this to the larger radii He will then plot his longitudinal section on a scale of 50 ft to 1 in longitudinally with a vertical scale suitably distorted; channel levels will also be plotted in relation to the crown level. The "running commentary" is transferred to the top of the sheet and notes made along the chainage as to levels, entrances, adjoining buildings, etc. The finished surface can then be regraded and vertical curves inserted having due regard to sight lines, drainage, etc

On a print of a 1/2500 ordnance sheet with everything blotted out except the line of route and its environs, he completes his "running commentary", marking those sections where a 1/500 survey has been made and those where vertical re-alignment is necessary. Cross sections are plotted also on squared paper to natural scales, and lastly the 1/500 surveys are plotted where improved horizontal alignment is required

With the exception of the latter sections, if his reconstruction is limited to that of the carriageway without the acquisition of property, he will superimpose on his large scale plans the largest radius obtainable within the limits of the highway with a circular curve to each channel and with transition curves on each approach He will then define his super-elevation, set out his new alignment on his cross sections with such widening as may be necessary, including extra width on curves compared with uniform carriageway width He will also set out his super-elevation on his cross sections and relate his verge levels to the new carriageway level, he will also transfer his new levels, where improved vertical visibility is required, to his cross sections, to ascertain whether cut or fill is involved to achieve the improvement

When this preparatory work has been completed on the lines described, all levels, details, etc become available to enable the reconstruction to be pegged out on the ground

Widening and Improvement

When a widening improvement is to be undertaken on a section of road it becomes necessary firstly to prepare a large scale survey to a scale not less than 1/500, or if it is a built-up area to a scale of 20 ft to 1 in, the detailed information to be gained from the ordnance sheet being insufficient to enable the work required to be accurately designed or to be set out on the ground More-over, quantities cannot properly be assessed from the 1/2500 scale sheets

As already described for carriageway reconstruction, a profile is required by taking levels at not more than 25 ft. intervals, or more closely spaced where rapid changes of gradient obtain;

cross sections are necessary at similar distances apart, or more closely spaced where there are particular features to be recorded such as buildings adjoining the road The survey must extend to at least 200 ft. on either side of the centre line and in any case be sufficiently large to include any buildings or other features of the terrain which adjoins the highway, the width must depend upon the proposed width of the improved road, but an overall width of 400 ft should be adequate to provide for widenings up to 120 ft or if the width required is less, the survey may be correspondingly reduced in extent. Similarly, cross sections must be levelled to a similar width so as to ensure that they are surveyed wide enough to allow of diversions of the centre line from its existing position

When the plan has been plotted it should be inked in so that the proposed widening can be superimposed on it in pencil without affecting the original work If, as may often be the case in this country, the work is to be carried out on a classified road and is subject to a grant from the Road Fund, or if a loan sanction is necessary, the Government Department concerned will require two or more copies of the plan showing the proposed improvement before authority will be forthcoming for the work to be carried out In such cases it will be necessary to prepare a tracing of the original survey so that reproductions may be made both for the aforementioned purpose, for exhibition to the Authority concerned, and where work is to be carried out by contract, for the contract documents and for use by the contractor on the job There are, however, machines now on the market which will produce copies from an original survey without the necessity for preparing a tracing, and in the larger offices this practice eliminates a considerable amount of tracing work

Assuming the road is to be widened so as to provide dual carriageways with an overall width of 120 ft, it is necessary firstly to define a new centre line, changes in the direction of which

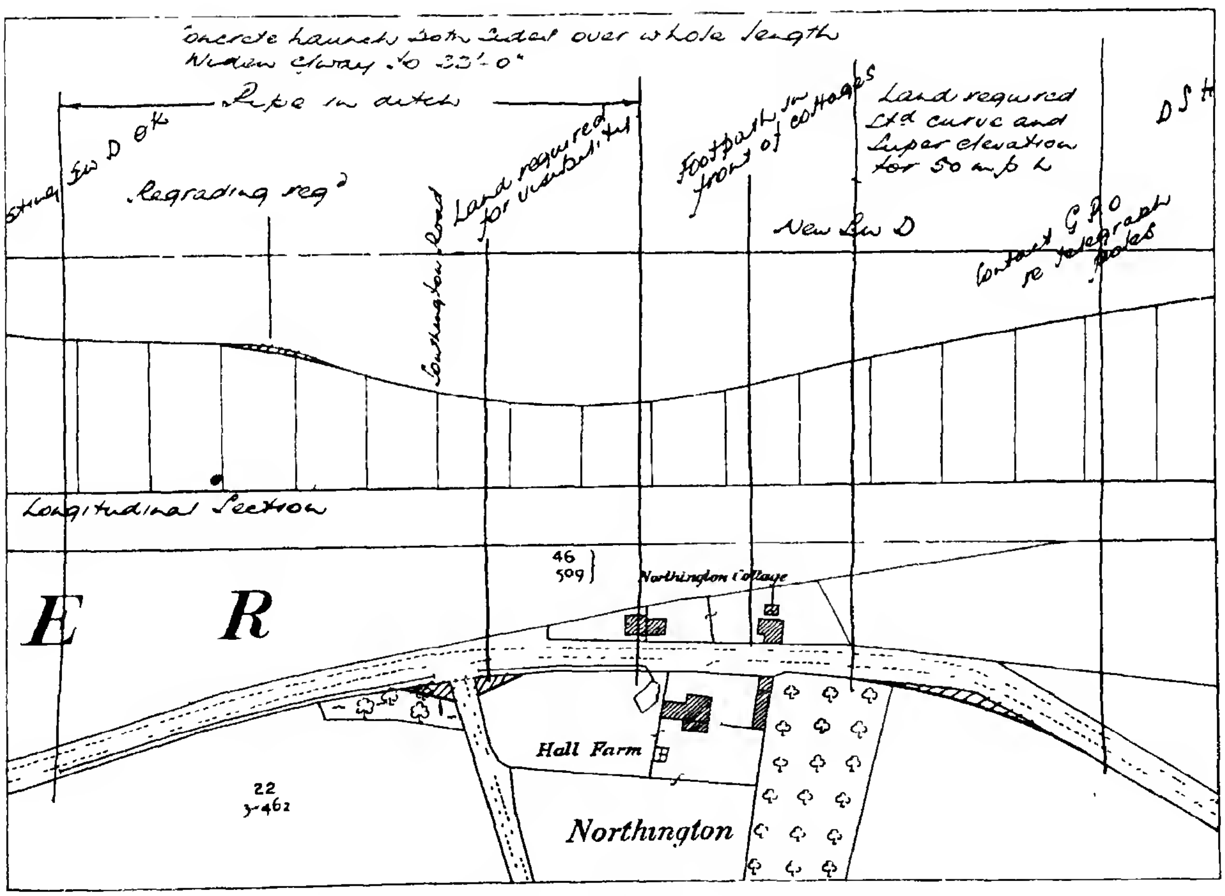


Fig. 3.—Typical "Running Commentary" for Widening Scheme

FIG. 4 —GLOUCESTER–ROSS ROAD A 40 LONG HOPE CORNER
(*a*) Looking towards Ross before improvement, June, 1935
(*b*) Looking towards Ross after improvement

should be connected by easy horizontal curves (see Fig 6) To this new centre line the remainder of the design is related, the carriageways being positioned according to the predetermined width of the central reservation In this connexion it is very desirable that the carriageways should be designed for line and level as separate entities, since they need not necessarily be related to one another either as regards gradient or alignment, there is, however, a limit to the gradient which can be efficiently negotiated by mechanically-propelled traffic, whereas with regard to footways and grass verges, these need not necessarily adhere to the same gradient as the carriageway nor need they be parallel to it, and in many cases can conform with the natural level of the ground In the case of cycle tracks, however, gradient is a vital concern, since cyclists are more controlled by gradient than mechanical vehicles, and therefore cycle tracks should be designed with the easiest possible gradient but alignment is of lesser importance The central reservation need not necessarily be uniform in width but a minimum should be fixed It is often desirable to increase the width of the central reservation to incorporate trees and other features of the landscape and as far as possible to depart from the monotony of uniformity of width throughout the length of the route

The plotting of the profile and cross sections, the grading of the carriageway and the design generally, should follow the procedure already described for carriageway reconstruction, but quantities of earthworks will require calculation Curvature, both in a horizontal and vertical plane,

FIG 5 —GLOUCESTER–PAINSWICK ROAD, B. 4073
(*a*) Improvements at Matson, looking towards Gloucester, showing curve
(*b*) Looking towards Gloucester from Painswick, showing road to Upton on extreme right and section of retaining wall on left

will also follow the procedure described, and where horizontal curves of less than 3,000 ft radius are inevitable super-elevation will be necessary. Figs. 4 and 5 show some road improvements in Gloucestershire.

New Road Construction

In the case of the preparation of a scheme for an entirely new road, while the ultimate plans, levels and sections required will in many respects conform to those described for road widening, there is a greater amount of preliminary work involved in locating the line of route, and only after considerable experience will the engineer be able to produce the most desirable results

The first consideration is to determine the general line of route depending upon the purpose which the new road will serve Assuming this to be a section of a new route as a substitute for an existing unsatisfactory route between two towns, the first consideration would be to ascertain the limits of the existing or the proposed (planned) built-up areas of the two towns. The general line of direction may then be defined on a 1 in scale map extending from a point outside the built-up area of one town to a similar point near the other. This line should then be regarded as a guide to the area of route selection, directness being the chief criterion unless there are other purposes to be served en route, such as a civil airport or satellite town

The next stage is to select the 6 in maps of the area and work out possible routes for investigation in the field In addition to contours, obstructions such as rivers, canals, flood land, railways, embankments, bridges, are all shown on these sheets and will enable the engineer to select alternative "paper" routes It then becomes necessary to attempt actual route selection on the site Only after considerable experience is the engineer enabled to assume possible gradients by inspection without the necessity for more detailed contouring than that shown on the ordnance sheet. With practice, however, it is possible for the engineer not only to recognize the best route by inspection but also to appreciate the engineering problems likely to be encountered on any particular line. The points to which he should address himself are many, including the following:

(*a*) *Alignment*—Horizontal alignment should be as direct as possible with long lengths of tangent joined by relatively short lengths of large radius curve, deviation angles being kept down to the minimum By limiting his location to 3° curves (1,910 ft radius) it becomes unnecessary to incorporate transition curves between the tangents and the circular arcs, and the ultimate setting out is simplified

Vertical alignment depends upon the ruling gradients to be observed, which should range between a maximum of 1 in 30 and a minimum of 1 in 250 Although vertical curves will be involved at changes in grade, it is not important to have regard to these during the location stage

(*b*) *Earthworks*.—It is a fundamental of civil

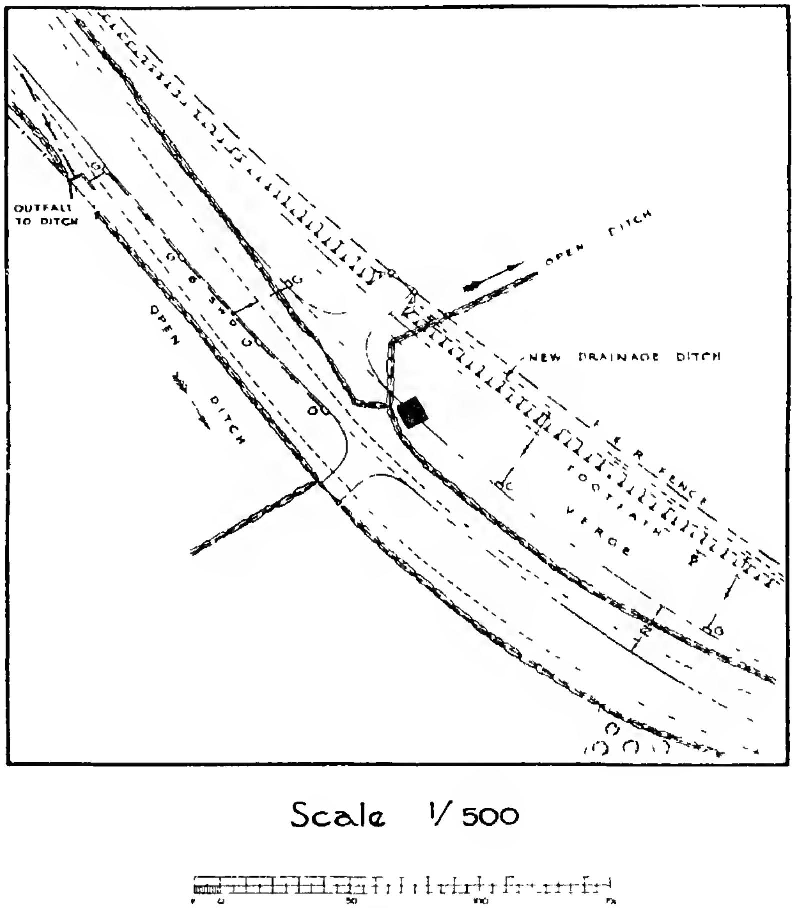


Fig 6 —Widening Plan

FIG 7—NEW BY-PASS ROAD IN REINFORCED CONCRETE WITH ASPHALT SURFACE, AT NORTON, ON THE GLOUCESTER–TEWKESBURY–BIRMINGHAM ROAD, A 38 1925

engineering economics that cut and fill should balance as near as possible within the range of gradient. Maximum permissible depths of cut or heights of embankment depend very largely upon the nature of the subsoil encountered, and in the case of heavy fills regard must be had to whether the subsoil lends itself to proper consolidation For example, clay is a difficult material to stabilize and therefore in the case of cohesive soils earthworks must be reduced to the minimum, even in some cases at the expense of gradient. With rock at the other extreme, heavy earthworks can be contemplated from the point of view of stability, but the cost of excavation and blasting for cuttings must be balanced against the much steeper side slopes possible and the value of the material for filling. Deep cuttings are objectionable from the point of view of loss of view of the surrounding country, while high embankments give the appearance of artificiality to the resulting road. The ideal is adherence as near as possible to existing ground level, and while no definite rules can be laid down, the best location for a road is most often to be found in gently rolling ground with easy cuts and fills alternating over reasonably short lengths

(c) *Drainage*—Natural drainage of the subsoil is a vital consideration in order to obtain a suitable structure, and from this point of view again gently rolling country provides the best conditions, since natural gradients are sufficient to ensure effective run-off without too rapid a concentration On side-long ground care must be exercised to avoid as far as possible springs and seepage of subsoil water into the road In low-lying flat country the location of drainage outfalls is an important consideration and may sometimes be the deciding factor in the final location of the route to be selected.

(d) *Obstructions*—River crossings must be selected where suitable sites for bridges can be found and where suitable approaches can be constructed. A straight reach of river is the most desirable, particularly as there is, on such lengths, the least risk of bank erosion. Banks should be such as to provide a suitable foundation to the abutments. Bridge spans should be as small as possible, but regard

should be had to any proposals by the river drainage authority for the widening of the stream Regard must also be had in the case of navigable rivers to the clearance height for river traffic, which will govern the design of the bridge and the height of the approaches Flood land should be crossed at its narrowest point, preferably where there is filling available from higher ground, so as to construct the road above flood level Canals do not normally present much difficulty to the location engineer. where a traffic crossing is required adjacent to a lock the best position for the crossing is downstream of the lock, thus minimizing the headroom required Railway crossings should be avoided as far as possible, but where a crossing is inevitable it is preferable to bridge over rather than under Over-bridges should generally have 15 ft height clearance over a railway track, and crossings should therefore be located over a cutting, which has a further advantage that the work can be carried out with little interruption to or from the rail traffic If under-bridges are inevitable, a suitably high railway embankment should be selected if possible, as 16 ft 6 in clearance over the highway is necessary and sunken roadways, with their attendant drainage difficulties, are undesirable

(e) *Access* —Suitable access must be provided to other main and local roads of sufficient traffic importance, but in other cases access should be restricted and as far as possible the new route should be located to avoid minor road crossings; where these are unavoidable crossings can be made by means of a bridge without a physical connexion between the two routes In flat country expense will often preclude bridging, and junctions must be provided for

The by-passing of built-up areas must be treated boldly to ensure that the new route is not encroached upon by building development, thereby becoming choked with local traffic It should be sufficiently far flung to avoid the close spacing of road junctions, preferably outside the main development area, without direct access from purely development roads Where passing through a built-up area is unavoidable, wide green belts or amenity strips on either side of the road prove an advantage

(f) *Severance* —Severance of ownerships is a factor which must be very carefully borne in mind by the location engineer; arable land is not usually depreciated to the same extent as pasture by severance from the homestead Exchange of land between adjoining owners can often be arranged so as to minimize severance, but the general aligument should not be prejudiced, although alignment can often be adjusted to follow reasonably near the boundaries between existing holdings

(g) *Airports* —The number and importance of civil airports will doubtless increase, and communications to and from them are factors which must be borne in mind in the location of new routes, especially as both road and air transport form intrinsic units in a comprehensive transport system

FIG 8 —FILTON BY-PASS, B. 4057 JULY, 1938

(a) Looking towards Bristol, showing general width of road.

(b) Looking towards Bristol, showing entrance to Aircraft Barracks on left.

Field Work

The field work falls into five main headings

(*a*) Test profiles
(*b*) Centre lines
(*c*) Levelling
(*d*) Detail surveys.
(*e*) Referencing

Test profiles are rough levels taken to prove the feasibility of certain lengths on a route or to establish a choice between alternative routes where the ground is too undulating to permit of a decision being reached by an inspection. A rough centre line is set out and levels taken either by dumpy level, or for very approximate check tests with a hand level.

The establishment of a centre line on the site is a very important part of the field work as it provides for the future setting out of the construction centre line and is the axis for levelling; it is also used for the setting out of the traverse on which the main survey is built up, and whilst this is being done permanent reference points can be provided for subsequent use

Levelling is carried out in the usual way in sufficient detail to obtain complete and accurate earthwork quantities for the preparation of the scheme Levels are taken on the centre line at each 100 feet and at intermediate points so as to obtain an accurate profile Cross sections are taken every 200 feet in easy country, and at additional points as may be necessary according to the nature of the ground to enable accurate quantities to be taken off

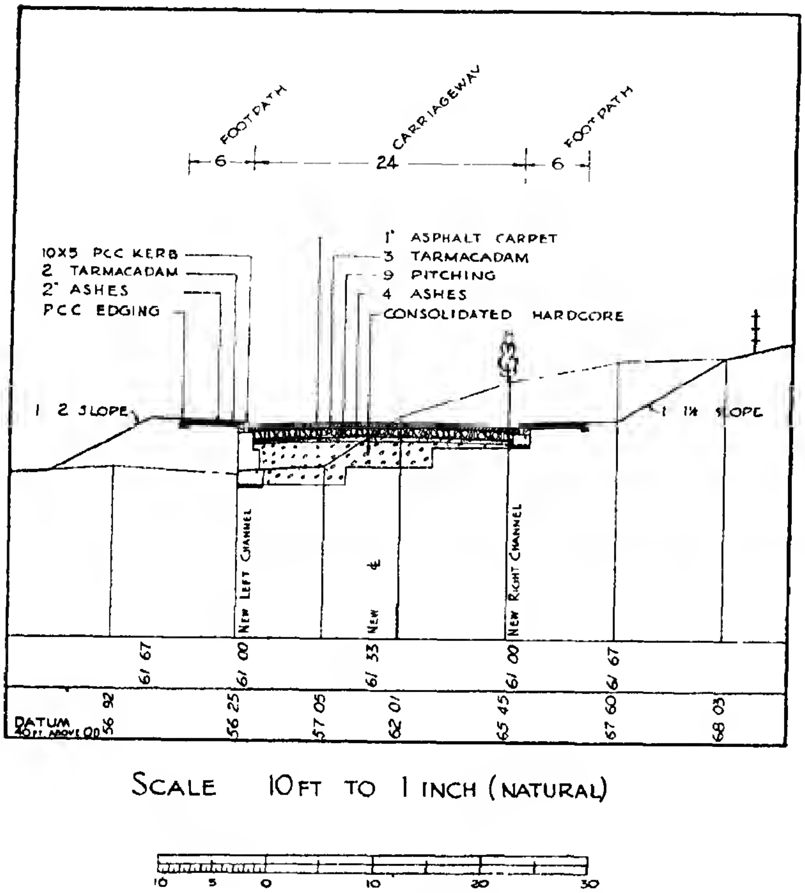


Fig. 9—Typical Cross Section of Widening

Engineering surveys are only carried out on priority sections or in built-up areas during the location stage When a line has been finally settled, however, a complete detailed survey is carried out as already described for road improvement

Referencing is important, i e. ascertaining all details of ownerships and holdings, tenancies, etc , as it is more convenient to obtain this in the early stages than to employ personnel solely to obtain this information after a decision on the location of the line has been reached.

Aerial Surveys

This article would not be complete without reference to aerial surveys. For original location work over long lengths of road in undeveloped country, aerial survey is undoubtedly the most up-to-date and rapid method of obtaining sufficient information to define a preliminary location and for obtaining key plans of an area through which a line of proposed route is to be taken. There are a number of aircraft companies experienced in undertaking this class of work, which is of a specialized character, and they are prepared to produce scale plans with contours on a contract basis, which has the advantage even in this country where ordnance sheets are available, of producing an up-to-date survey in the shortest possible time. Many of the ordnance sheets are now out of date and recent development and buildings are not shown thereon.

The extent to which aerial survey has been used

FIG. 10 READING BRIDGE, HENNEBIQUE SYSTEM CLEAR SPAN OF 180 FT
(*Engs L G Mouchel & Partners*)

for war purposes is not yet common knowledge, but there is little doubt that considerable advance has been made in the technique, and it is more than probable that there are or soon will be new undertakings ready to carry out this class of work. Any engineer who seriously contemplates this method would be well advised to discuss the matter with the Ministry of Civil Aviation, who may be able to put him in touch with competent firms. It is not possible to set out even the fundamental principles of aerial survey in a reference book of this nature, as the subject is a highly scientific and complex one on which a complete volume could be written. Engineers concerned, however, are referred to the libraries of the Institution of Civil Engineers and the Royal Aeronautical Society for suitable books on the subject.

DRAINAGE

The highway engineer is primarily concerned with subsoil and surface water collection and

FIG 11.—PUDLICOTE MILL BRIDGE, CHIPPING CAMPDEN–STRETTON-ON-FOSSE. UNCLASSIFIED ROAD

(*a*) Before reconstruction, abutments scoured, arch collapsing

(*b*) Reconstructed 1932–33, Cotswold stone parapets and string course, ferro-concrete bridge with buff-coloured concrete on the elevation.

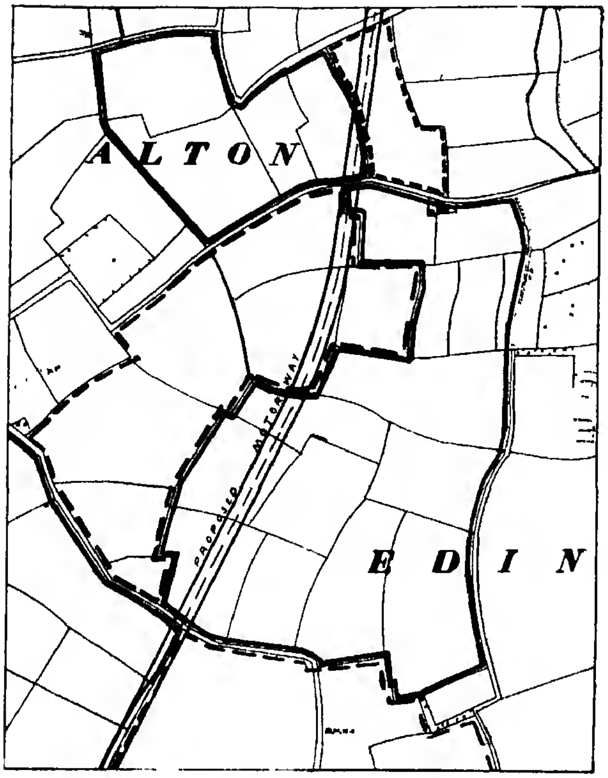


FIG 12—TYPICAL LOCATION SHOWING BOUNDARIES OF FARM HOLDINGS

disposal and not with foul sewers, except in so far as the latter may be located within the highway.

SURFACE WATER

The responsibility of the road engineer is to dispose of the water collected upon the surface of the highway, and he has no other liability. There may be water-courses and ditches within the limits of the highway, but except so far as these may have been constructed solely for the drainage of the highway, the engineer has no responsibility for their upkeep, although he may have the right, and may exercise it, to drain highway surface water into them.

Surface water from highways may be disposed of in several ways depending upon whether the road is situated in an undeveloped or built-up area In rural areas disposal by means of grips into open ditches is the simplest method, and provided the ditches are fairly remote from the metalling it is reasonably satisfactory. It is fool-proof provided there is adequate longitudinal fall on the carriageway. Grips should be cut so as to take the flow of surface water in the channels at intervals and so as to prevent a heavy accumulation in the valleys or points of run off.

Surface water is generally concentrated by means of a cambered carriageway, the degree of slope depending on the nature of the surface. For example, 1 in 45 slope is sufficient for concrete or other smooth surfaces, but where a coarser texture is involved, crossfall of 1 in 36 to 1 in 40 is desirable Channels should be carefully levelled so as to conform to gradients adequate to ensure that a reasonable rate of flow is obtained without being so steep as to concentrate too quickly on run off points, the ground may be such, however, that the latter is unavoidable, when greater capacity at the run off is required

In built-up areas and on other roads where the open drain method is undesirable, the common practice is to provide either (*a*) gulleys in the channels or the immediately adjacent verge with vertical fall gratings, or (*b*) the kerb inlet type The former have the advantage of being in the direct flow and are consequently more efficient, but they require careful setting flush with the channel so as not to create a "jolt" to passing traffic; if they stand proud or are unevenly set, damage may accrue to the grating and cause discomfort to the vehicle The kerb inlet type has the advantage of being clear of the traffic lanes but there is a tendency for surface water to pass by if the velocity is high. See Manufacturers' Data following Section Five.

Gulleys are connected to surface water drains consisting of socketed pipes increasing from 6 in diameter upwards dependent on the quantity of water to be disposed of and the gradient to which the drain may be laid There are several well known formulae upon which surface water piped drains may be designed

SUBSOIL DRAINAGE

The drainage of subsoil water in certain classes of soils is often as important a factor in the stability and life of a road structure as the collection and disposal of surface water; in some cases it may be more important and is often of paramount importance.

Soils such as sand, gravel and brash may be regarded as self-draining and subsoil drainage is seldom necessary in roads built on such sub-strata. With cohesive soils such as clay, subsoil drainage is vital. Subsoil drains usually consist of porous pipes laid to falls below the metalling with open joints connected to the main drain or open ditch. They should be laid in clinker or ashes or similar filtering media sufficiently enclosed to be protected from choking by silt carried in suspension in the water.

Adequate subsoil drainage in waterlogged subsoils may mean the difference between a suitable and unsuitable subgrade upon which the road is to be founded.

In the case of very flat country it may be necessary to provide artificial gradients in road channels between gulleys to obtain a satisfactory run-off for surface water.

GRADIENTS

In highway design or redesign the question of gradient is important for various reasons In the first place there is an upper limit above which modern vehicles cannot travel in comfort and which commercial vehicles carrying heavy loads may not be able to negotiate at all At the other extreme there is a lower limit below which it is difficult to drain subsoil water, as the movement of the latter becomes so sluggish that the slightest irregularity in the surface of the road will cause ponding, with the consequent risk of the road metal perishing and failure of the surface resulting.

Gradient is not always controllable and in mountainous or hilly country it is often impossible to adhere to a desirable maximum To conform to a maximum gradient in such country recourse must often be had to detours of alignment so as to climb spirally between contours. To determine a route for a road in such circumstances close contouring forms an invaluable help to the engineer It is interesting to note that natural gradients often determined the route of ancient highways and that these routes were varied from time to time according to the prevailing means of transport, for example a pedestrian can negotiate a steeper gradient than a wheeled vehicle.

Where gradient can be controlled the usual maximum adopted in this country is 1 in 30, which is a top gear slope for all but the heaviest class of commercial vehicle It may, however, on occasions be better to forfeit some advantage in gradient for the sake of reducing the depth of a cutting or the height of an embankment, especially in the case of the former where the landscape may be hidden by deep slopes This does not apply, of course, where the gradient is near the extremes

Between 1 in 30 on the one hand and 1 in 250 on the other, gradient should approximate as far as possible to the "natural lie of the land", but the aim should be to achieve reasonably long lengths of uniform slope. All changes in gradient either on peaks or in valleys should be joined by vertical curves, the primary object of such curves being to ensure adequate visibility at peaks and comfort to passengers of vehicles negotiating changes of grade at speed both at peaks and valleys.

MAIN HIGHWAYS

The main highways of this country may be broadly divided into three classes, namely, Trunk, Class 1 and Class 2 roads

Trunk roads are included in the Class 1 category but the majority of Class 1 roads are not trunk roads Outside the towns, where there are different categories of road according to the size and status of the town, the classified roads are county roads for which County Councils are the Highway Authorities with the exception of the trunk roads for which the Minister of Transport is the Highway Authority The County Councils act as agents for the Ministry of Transport for the upkeep and improvement of the trunk roads Both trunk and county classified roads pass through towns but in the case of county boroughs the term "county" does not apply, as the Borough Council is the Highway Authority

In 1919 the Ministry of Transport Act empowered the Minister to classify the main roads, and as a result the more important of these roads were numbered and divided into two classes; the Class 1 roads were prefixed with the letter "A" and the Class 2 with the letter "B"; thus the Great North Road became A 1 Since 1919 many changes have been made in the list, mainly by way of additions due to reclassification, but the original framework remains substantially as it was created in 1919

In 1936 the Minister of Transport was created the Highway Authority by the Act of that year for 4,500 miles of the most important Class 1 roads in the country, which from then onwards were known as the trunk roads. In 1946 a second Act was passed adding an additional mileage of between 3,000 and 4,000 to the Trunk Road Schedule, and this Act came into force on the 1st April, 1946.

The large majority of main roads have a single modern surfaced carriageway usually varying between 18 ft and 22 ft wide; there is, however, a substantial mileage of 30 ft. carriageway and some miles of 40 ft carriageway There is a relatively small mileage with dual carriageways which is the form of construction now recognized as the most desirable for main roads.

The principle of segregation of the various classes of road users is now acknowledged as

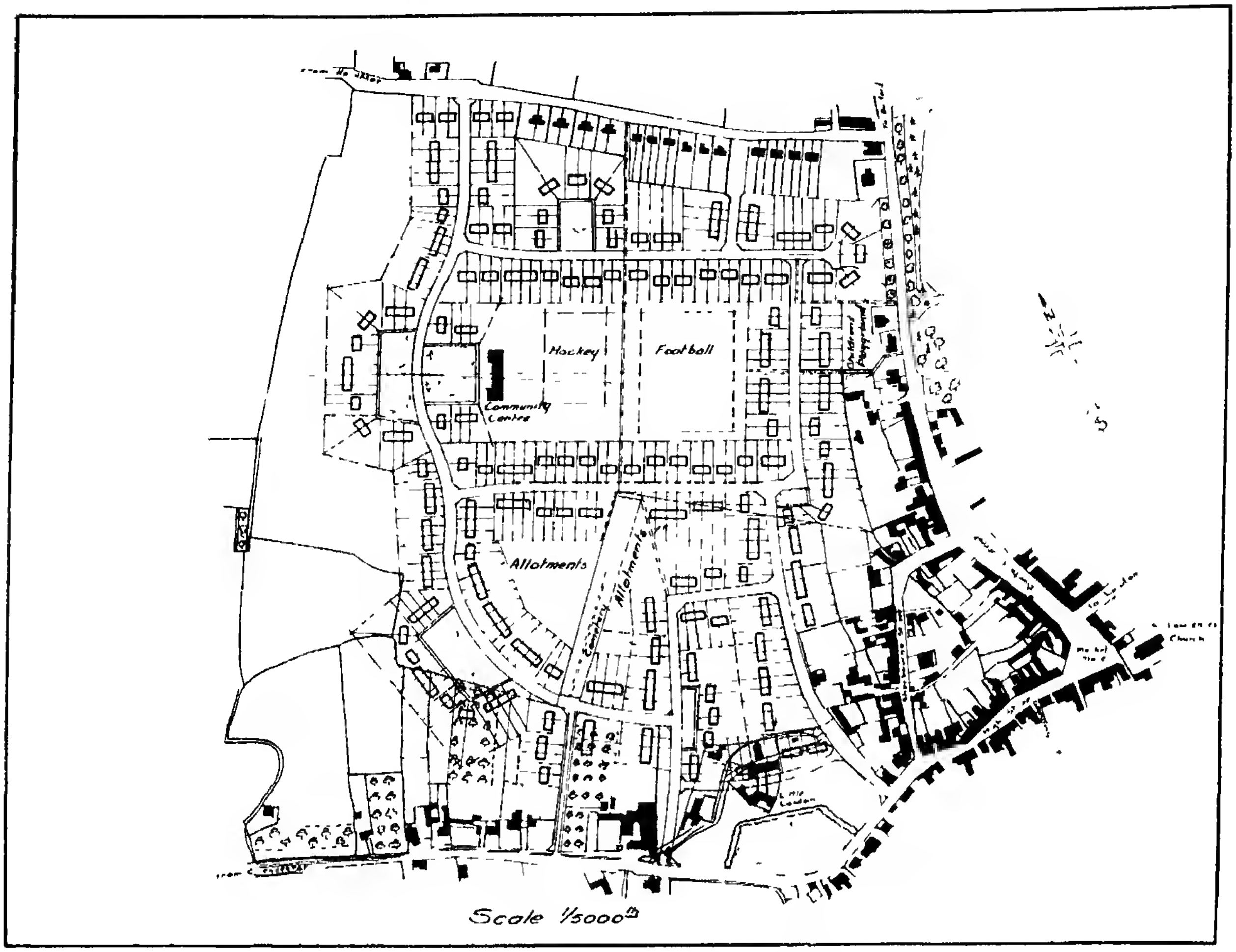


FIG 13—PLAN SHOWING "GROUPED DEVELOPMENT" FOR NEW HOUSING

essential in the interests of safety; this principle comprehends dual carriageways, one being reserved for each of the opposing streams of traffic and separate tracks for cyclists and paths for pedestrians Up to the war of 1939-45 conversion of trunk and Class 1 roads to this form of construction was being undertaken slowly, but there is a very large mileage yet requiring conversion.

The principle of right of access to main highways is one to which considerable attention has been paid in recent years, primarily as a safety measure, based on the view that at every point on a main road where free entry is permitted a risk of collision obtains. Whilst the control of access to main highways was secured comparatively recently, as these roads are intended primarily as traffic arteries, it is fundamental to the conception of a main road that it should not be used for secondary purposes such as a service road to a row of houses or shops

Under the Restriction of Ribbon Development Act 1935 Highway Authorities are empowered to control any new access to the main road, and no new entrance can be laid out without the consent of the Highway Authority, who have power either to refuse or give consent, subject to conditions.

The term "main highway" is generally interpreted to mean the most important roads of the country, but the term has now no exact technical significance. Originally the "main" roads were those for which County Councils were the Highway Authority before 1930, when the least important roads were maintained by the various district councils, i.e. borough, urban and rural district. When, under the Local Government Act 1929,[1] all roads in rural districts were transferred to County Councils as the Highway Authority, the term "main road" disappeared and "county road" was substituted.

Non-county boroughs with a population of 20,000 and over have the right to "claim" to maintain county roads which pass through their town In the case of these authorities, although the Borough Councils carry out the work, they are financed by the County Council from their general county rate, estimates of expenditure have to be submitted to and be approved by the County Council annually, and subject to this the work carried out by the Borough Council is met wholly from county rate funds The improvement of county roads in such boroughs is similarly financed but the Local Authority can be called upon to contribute towards the cost when an improvement can be said to include an element of town improvement

Trunk roads are financed by the Ministry of Transport as the Highway Authority, and in the case of the Agent Authorities, in addition to the cost of the work carried out a percentage addition for overhead charges is paid by the Ministry

Classified roads are grant earning, the Minister of Transport is empowered to make grants from the road fund towards the cost of maintenance and improvement of classified roads subject to the road work being carried out to the standard of construction laid down by the Ministry In the case of Class 1 roads, the present rate of grant is 75 per cent and for Class 2 roads 60 per cent

From the 1st April, 1946 the Minister of Transport has created a third category of classified roads known as Class 3, which comprises the more important local roads serving certain defined purposes including agriculture The rate of grant for this class of road is 50 per cent

The Engineer responsible for main roads maintained by County Councils is known generally as the County Surveyor, as a rule he is a Chartered Civil Engineer, and has under his control a staff of road engineers, accountants and clerks He is responsible to the County Council for the technical work of maintenance and improvement of trunk and county roads, and most counties are organized on a system whereby the county is divided into areas for which a Divisional Surveyor is responsible to the County Surveyor Each Divisional Surveyor having charge of an area is responsible for the whole of the executive work in connexion with the maintenance of roads in his area and

Fig 14—Stow-on-the-Wold–Moreton-in-Marsh Road. A. 429 Roman Road, Fosse Way
Section of Roman road fenced off one mile north of Stow-in-the-Wold, showing Roman edge-set stone foundation work

has direct control of the labour employed. The other technical and administrative work is normally carried out by the Headquarters Staff of engineers and other administrative officers

In the case of improvement work on trunk and county roads, the preparation of plans follows a recognized pattern. Each trunk and county road improvement eligible for grant has to be submitted in detail to the Ministry of Transport before consent to the work being undertaken is forthcoming. Usually a plan to not less than 1/500 is prepared, indicating the nature of the scheme with the proposed improvement shown thereon accompanied by levels, cross sections, bills of quantities, estimates, etc. The widening of existing, or construction of new, bridges on main roads is treated similarly, but large scale detail plans are prepared for submission to the Ministry, together with a copy of the design calculations. In the case of a bridge of some magnitude, the proposed elevation has to receive the approval of the Fine Arts Commission

It is the normal practice for the expenditure on main roads to be recorded by a system of costing whereby the individual costs of the larger works become available together with unit costs of individual items of work, which are taken out for comparison with the estimates prepared for the individual schemes. In some offices the costing is done by mechanical methods involving the use of accounting machines such as the Powers-Samas Punched Card System.

As main roads are administered by a public authority and as the expenditure thereon is met from rates and taxes, it is the normal practice for annual tenders to be obtained by public advertisement for the supply of materials and services. Materials include all items from road stone for foundations to materials such as asphalt, tarred macadam and stone chippings for surface dressing Tenders are usually also invited for miscellaneous stores such as pipes, kerbs, etc

Most of the maintenance and improvement work on main roads is carried out by direct administration, but bridge construction, surface dressing and of recent years road improvements and road surfacing, are often carried out by contract. The development of mechanical methods of road surface laying has lately brought contracting back into road surfacing work which was previously undertaken by hand by direct labour. The best known machine of this type is the Barber-Greene road surface layer, which if properly supplied, can lay up to a maximum of 400 tons per day of tarmacadam and 80–100 tons per day of asphalt carpeting.

The upkeep of main roads and the general administration connected therewith has developed during the last quarter of a century into a scientific profession with its own technique, and can no longer be regarded as a part-time job for a farm hand, as was usual in the old days of the parish surveyor of highways.

BY-PASS HIGHWAYS

The majority of the major highways of this country have developed from ancient roads or tracks, many of them following the original routes of the Roman roads and many being of earlier origin Few trunk arteries have been constructed as such, in fact it has been said that there has been no major road construction in this country since the Romans left in 410 A D

There was probably a deterioration in the use of long distance routes for many centuries, as the means of transport in vogue in the middle ages was so restricted that only local roads were important and many of the long lengths of Roman road fell into decay, became overgrown and some may have reverted to agricultural land

It is necessary to examine the historical background in order to appreciate why most of the present trunk roads pass through numerous villages and towns, often forming part of the main streets and shopping centres thereof, to understand why there are long lengths of restricted width and why the alignment is often inferior. These trunk roads are to a large extent made up of short lengths of local road, but there are a few exceptions, particularly those routes based on the Roman framework. In some cases it can be seen that the Roman road has been adhered to in open country but the modern route has been diverted so as to serve a particular township, whereas the original Roman route by-passed what is now the built-up area

The development of the motor vehicle has brought with it congestion in towns and village streets, and this congestion is accentuated by the long distance traffic using the trunk roads having to pass through the narrow village streets. Of recent years it has been acknowledged that in the case of the smaller towns and villages not forming a normal terminus for long distance traffic, it is desirable to by-pass the built-up area. Such a by-pass road serves a dual purpose in that by attracting the through traffic to use it the latter is enabled to travel more freely and quickly to its destination and at the same time the congestion in the town or village streets is eased to the extent that the long distance traffic is excluded.

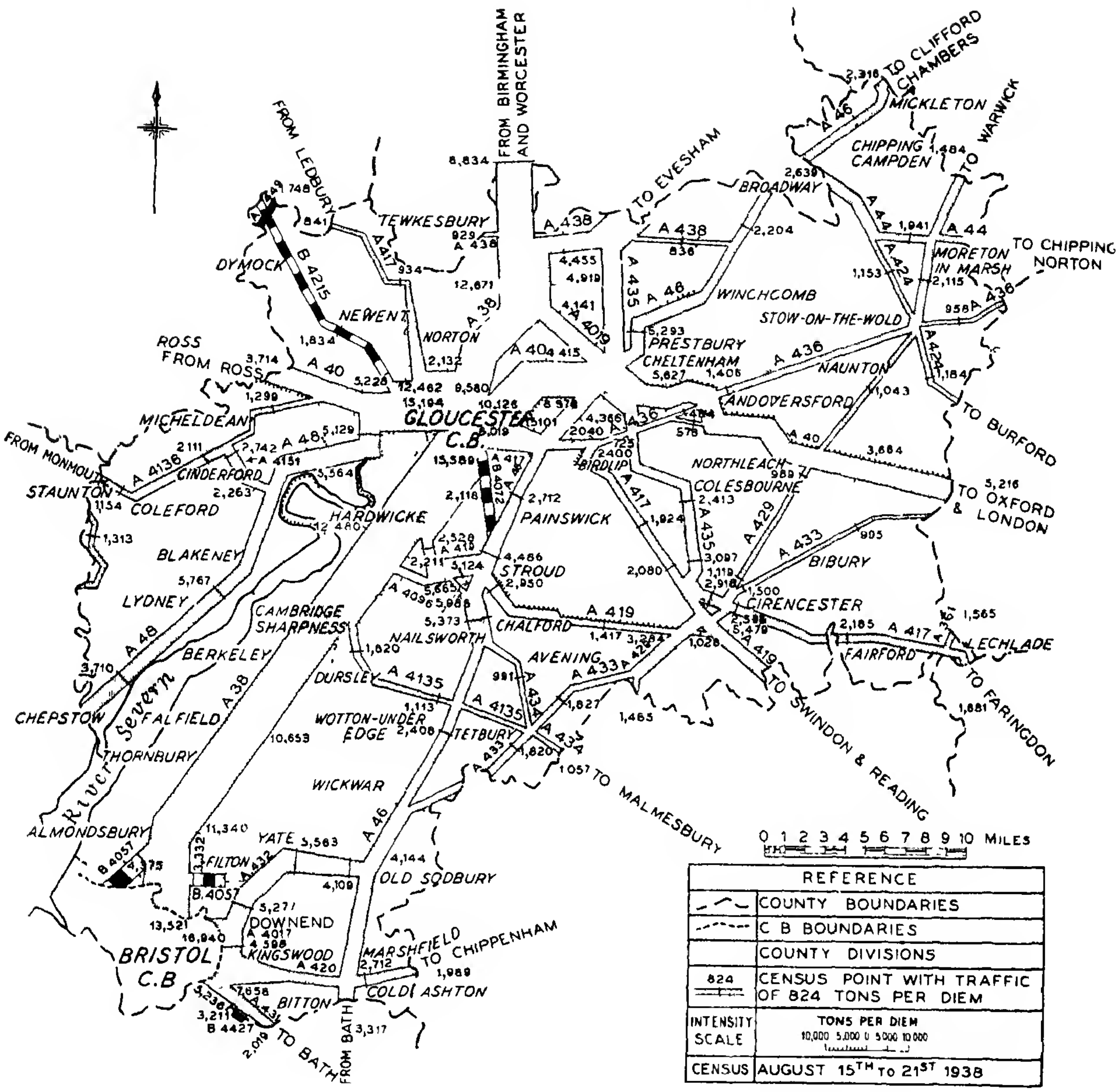


Fig 15 Typical Census Sheet

The by-pass road is therefore a very desirable provision for many of the towns and villages of this country served by trunk and Class 1 roads There are, however, certain exceptions, such as the very large cities like Liverpool, Manchester, Leeds, Birmingham and others Owing to the size and industrial importance of the city it is found that the majority of the vehicles using the main roads entering or leaving these cities either start or terminate their journey there. In these cases, therefore, whilst means are desirable for passing long distance traffic through the city without entering the congested central area, a by-pass road as such contributes little to the reduction of congestion in the main streets of the city It is therefore of extreme importance that the major arterial road entrances or exits to the large cities should have adequate capacity for a high density of traffic.

In locating a by-pass road to a town of say 20,000 to 50,000 population, regard must be had to a number of factors Firstly information should

be obtained as to the general movement of traffic in and out of the town and the proportion of the total movement in certain directions; if this is to be accurately assessed a traffic movement census must be taken to determine the general trends (see Fig. 15). This presents a difficult problem as it can only be carried out by stopping every vehicle entering and leaving the town on the approach roads and asking the driver his destination An alternative but less satisfactory method is by recording registration numbers, but this is much more nebulous in its results, as many vehicles may be lost and the "lost vehicle" must be regarded as those terminating their journey in the town

Having ascertained the general trend of traffic movement it must then be decided between which directions the loop or by-pass road is needed, or in other words which routes entering and leaving the town must be connected together without passing through the centre Where approaches in all directions appear to be equally used it may be necessary to construct a ring road completely encircling the built-up area and connecting all approach roads together In most cases, however, the definite need can be determined between two or three roads and the problem becomes simpler

The next information required is the extent to which the town is likely to expand, particularly on the side chosen to be by-passed This can best be decided upon by examination of the planning maps or by seeking information from the Planning Authority. A knowledge as to the future expansion of the town is essential, as the by-pass road should be so located as to enclose the whole of the built-up area, both present and future, in order to prevent buildings springing up on the by-pass road itself or on the side of the road remote from the town. So many ring roads and by-passes have been rendered unsatisfactory for their primary purpose by building development adjoining them that the foregoing aspect must be given most careful consideration at the location stage On the side of the proposed road nearest the town a further safeguard against encroachment by building development is the provision of an "amenity belt" which consists of a strip of land acquired by the Highway Authority adjoining the by-pass road, which is sterilized so as to prevent buildings being erected thereon

The engineer, having decided the two foregoing preliminary points, can then proceed to locate the by-pass as described under "New Road Construction"

Apart from the foregoing considerations by-pass roads do not differ from any other new highway and depending on the classification and importance of the roads which the by-pass will connect, so the lay-out will conform to either dual or single carriageway construction, with or without the provision of cycle tracks, and, if it is to be an all-purpose road, with the provision of footpaths for pedestrians

TOWN STREETS

By E L LEEMING, M Sc.Tech., M I.C E

THE recent drive for road safety under the auspices of the Ministry of Transport is an important step towards reducing the accident rate on our public highways The Committee on Road Safety issued a valuable report, with recommendations, on this question and naturally most of their proposals concern the city streets and congested areas where the accident rate is likely to be high Among their recommendations are the following

(1) To implement the segregation of traffic
(2) Traffic signs and signals to be improved.
(3) Parking in busy streets to be prohibited
(4) Adequate parking space to be provided
(5) Street lighting to be improved and obstructions on highways to be removed as quickly as possible

The Ministry of Transport has more recently issued a report on the Design and Lay-out of Roads in Built-up Areas. This report also gives some very valuable information and suggestions for dealing with road traffic in city areas

Roads are dealt with under five headings, viz

Arterial Roads	Local Through Roads
Through Roads	Local Roads
Development Roads	

In addition to these there are the single purpose road and the motorway

ROAD DESIGN AS PART OF REGIONAL PLANNING

In all the centre areas of large provincial towns the design of ring and radial roads requires to be related to the lay-out of other roads beyond the limits of the built-up area, thus the road pattern should be laid out as part of the regional plan It seems likely, therefore, that every large town will have at least an inner and an outer ring road, or their equivalent, as well as radial roads, in addition there may possibly be an intermediate road, and it is in connection with these local roads that car parking should be considered.

THE EFFECT OF "DISPERSAL" ON TRAFFIC

It should be borne in mind that in dealing with built-up areas we are inclined to accept the development as it already exists and to disregard the effect of new town planning legislation for new towns and "overspill", with its consequent redistribution of industry. On the other hand, it is inevitable that the present high density of population in London and the provincial centres will compel urgent attention to these matters. One question which should be examined is the relative cost of the effort to improve road conditions for traffic as compared with the cost of dispersal, in fact it might well be argued that it would be cheaper to re-build some provincial cities on an entirely new area rather than enter upon the laborious and expensive plan of reconstruction of the existing town with elevated roadways, costly intersections and subways It often happens that there is no physical or geographical reason why a town should remain on its particular site.

ALTERNATIVE ROUTES IN CITY AREAS

Traffic is gregarious and often prefers to adhere to the busy main road instead of taking a quiet alternative route In town areas, therefore, it is desirable to give encouragement to traffic to use a parallel alternative route in order to relieve the main popular thoroughfare which carries public service vehicles and a large number of pedestrians By the use of "Halt" signs the alternative route can be used without interruption. It may be that two alternative routes, one on either side, are available, and in such cases a one-way traffic scheme may be operated.

A SIMPLE FORM OF UNDER-PASS

Where there is sufficient width at an intersection the method of constructing an under-pass road is worthy of consideration An example of an under-pass road is that of the tram subway in Kingsway, London Imagine what this would mean if it could be used by other vehicles as well as trams! Often an under-pass road carrying one way traffic would be invaluable; no doubt one of the objections would be the question of mains and sewers, the depth of which may interfere with the construction of a subway at a minimum depth

If a two-way under-pass road only were considered, much could be done in congested areas To under-pass a busy main road is the same thing as to under-pass a railway. Figure 1 shows an example of an under-pass road, built prior to the war, at Reno, Nevada In this case pedestrians were allowed to continue using the level crossing and practically no provision was made for them on the under-pass road.

DESIGN OF TRAFFIC CIRCLES

Can a traffic circle be too large? The answer is "No," but it *can* be too small With the large circle there is less need to slow down and it may well happen that there will be a saving of time as against passage around a smaller circle where slower speeds are a necessity

As mentioned elsewhere, correct super-elevation is essential both for the approaches and the road surface round the circle itself

The width of the carriageway should be sufficient to carry two lanes of traffic comfortably and to allow additional space for cyclists as distinct from cycle tracks; thus 30 feet might be regarded as a minimum.

An example of a circle lay-out is shown in Fig. 2; pedestrian crossings are shown to link with the dividing islands; these should be of considerable length where possible, and of a tapering shape to conform to the transition curves at the entrance to the circle. A "traffic prow" at the narrow end of the separating island would make for a safer condition in the event of a collision (Figs. 3 and 4).

As an alternative to the circle, a convenient shape is an ellipse: this will afford better speeds for the main road "through" traffic, while the other roads may be controlled by "Halt" signs. Variations of this are given in Memorandum No. 575 of the Ministry of Transport; the centre island of the main road is widened and intersected to enable traffic to enter the road either to the left or to cross over to the right

FIG 1 —REMOVAL OF LEVEL CROSSING BY UNDER-PASS ROAD, RENO, U.S A.

Subways and footbridges are not likely to be popular in spite of the safety advantages. It should be remembered that the pedestrian and the cyclist are as important human beings as the driver of a motor vehicle

SIGNALS *versus* "HALT" SIGNS

The "Halt" sign as a safety device has not yet been fully appreciated in this country. In America the main road has the prior right of way and branch road traffic of all descriptions must come to a stop; this becomes a habit and no one seems to disobey the rule Signals are not an unmixed blessing; to hold up traffic on a heavily used main road for a few vehicles wishing to enter from a branch road is bad planning of traffic movement. A "Halt" sign will often achieve the same purpose as a signal On the other hand if the main road traffic is too dense for other vehicles to enter, then they should find another point of entry more suitable

FURTHER USE OF THE "HALT" SIGN

A more extensive use of the "Halt" sign could be introduced with advantage to all forms of traffic as enumerated below.

1. "Halt" signs at all entrances to major roads, i e Trunk Roads, Class 1, Class 2 and possibly Class 3 Roads
2. The "Halt" sign must protect cyclists and cycle tracks
3. The "Halt" sign should be employed where a minor road intersects a major road, i e. at a junction of a Class 2 Road with a Class 1 or Trunk Road

An example of how complete protection may be obtained on a main road by use of "Halt" signs throughout is shown in Figure 5

WHITE LINES

White lines are used for the following purposes: street refuges, traffic islands, lay-bys, etc.; transverse stop lines at road junctions where traffic is controlled by the police, by light signals, or by "Halt" signs. Such lines should be continuous and of a width of 6 in. They are also used to indicate curves (vertical and horizontal). If required

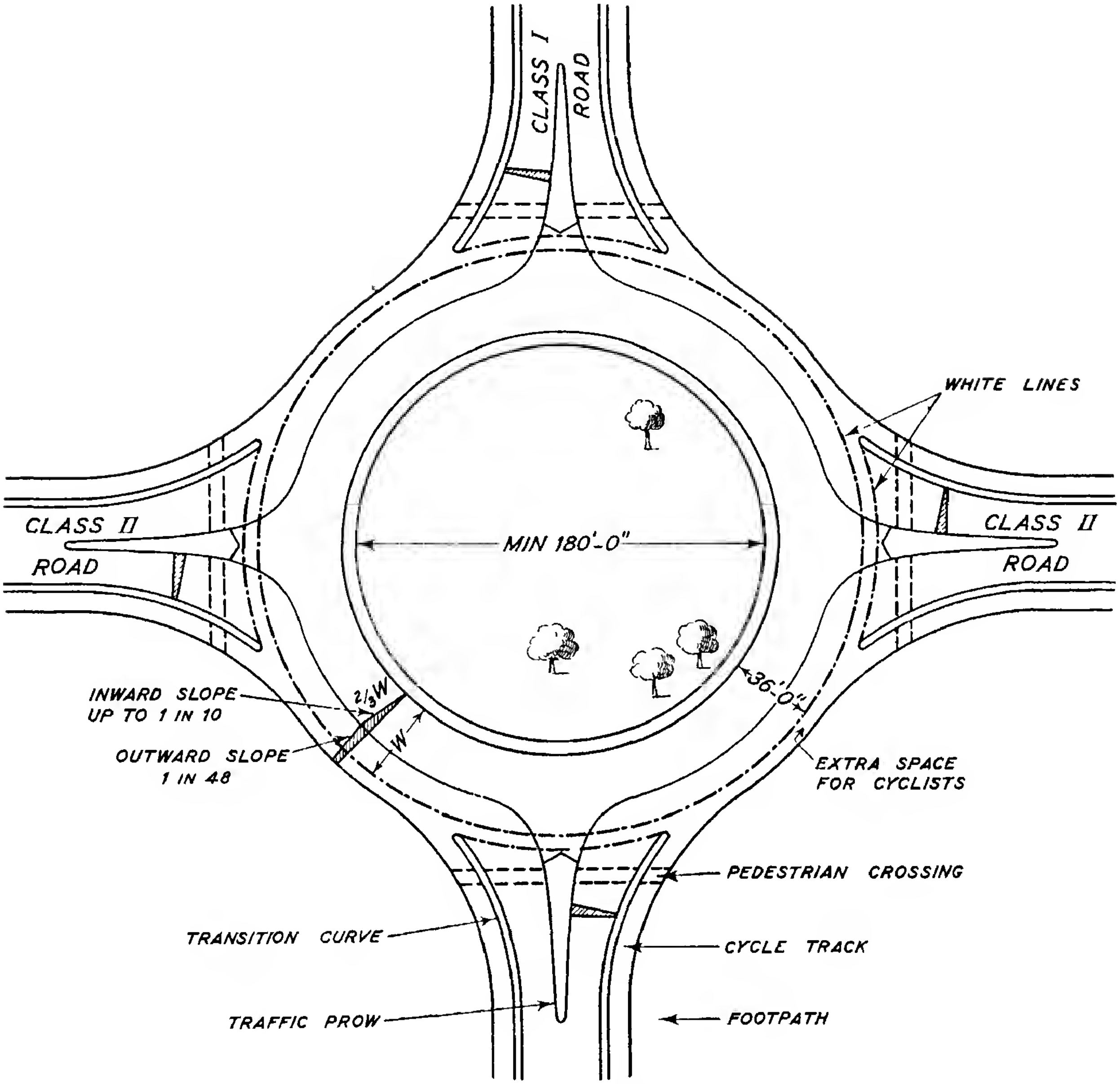


FIG 2.—LAY-OUT OF TRAFFIC CIRCLE

allowance can be made for filtering to the left by stopping short at least 8 ft from the near edge of the carriageway; the lines should be at right angles and well clear of pedestrian crossings

At controlled junctions lines should be at right angles and clear of pedestrian crossings

Longitudinal lines on carriageways should be 3 ft long with a 15 ft. gap.

There should be continuous white lines at bends on two-way carriageways with less than 500 ft. sight lines, also on three-lane carriageways with less than 1,000 ft. sight lines.

REFLECTOR STUDS

Reflector studs can be employed where the standard of street lighting is low. On intermittent lines the studs should be set in the centre of alternate gaps, i e at 36 foot centres; on continuous lines the spacing should be 12 feet

EFFECT OF THE TRUNK ROADS ACT

The Trunk Roads Act marks an important step in the national administration of highways; a

further 3,685 miles of roads have been included as Trunk Roads, including certain selected routes in County Boroughs, which will avoid the main centres of development and form links in the Trunk Road System. The Minister of Transport now has power to reorganize the Trunk Roads System by the inclusion of existing and new roads.

FIG. 3—TRAFFIC PROW AT SALT LAKE CITY, U.S.A.

Where one-way traffic is necessary a second route serving points on the trunk route may be included in the system. Provision is made for the construction, as part of the trunk routes, of cycle tracks and footpaths for use in connection with a trunk route, separated therefrom by intervening land, as for example woodland up to a distance of 220 ft. from the carriageway.

Clause 4 contains powers to remodel junctions and intersections of trunk routes with other routes and to stop up, in the interests of safety, junctions of other routes with trunk routes and to provide alternative connections where necessary.

The Minister also has powers to acquire land adjacent to the road for the preservation of amenities.

Powers are granted for the construction, as part of the trunk road system, of bridges and tunnels over or under navigable waters; privately-owned and maintained bridges carrying trunk roads will pass into public ownership.

The cost of construction, maintenance and repair of such roads is to be defrayed out of the Road Fund.

FIG. 4.—TRAFFIC PROW AT URMSTON, NEAR MANCHESTER

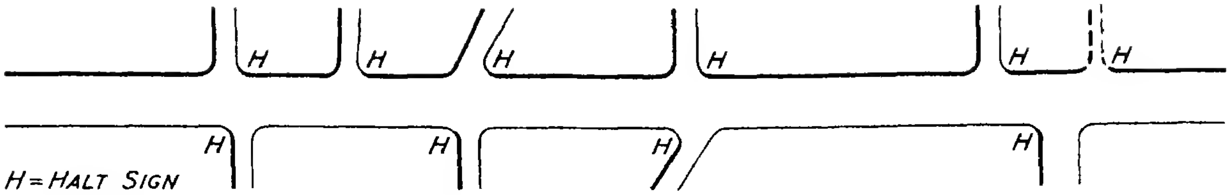


Fig. 5 Main Road in Built-up Area, Protected by "Halt" Signs for Side Roads

PROVISION FOR PUBLIC SERVICE VEHICLES

In view of the promise of co-ordination or nationalization of public transport an increased use of public service vehicles on many of our city streets may be expected, and it is essential that full provision should be made for them.

In approaching the problems of traffic the question as to whether there is a real public need for the presence of all the vehicles upon the highway is apt to be overlooked. When at peak periods hundreds of private cars each driven by one person are seen, there does seem to be an indication of unfair monopoly of the highway and of an increase in the danger to the general public. Eventually a point of saturation is approached when in city centres it is often quicker to walk than to ride, although it may not be "easier to breathe".

This condition had been reached in American towns before the war and, no doubt, that is the position to-day. In such towns many owner-drivers refrain from using their cars because of parking difficulties and use public transport instead. In one town at least the congestion in the city was so great that enterprising garage proprietors on the fringe of the town created car parking accommodation and ran small buses for the owner-drivers to take them into the city, collecting them in the evening and returning them to the car park. Large store emporiums adopted the same policy. This relieved the congestion and reduced the need for car parking facilities in the centre of the town. The advantage of providing adequate car parking accommodation is fairly obvious and in the case of places of public resort the car parks may require to be of fairly extensive dimensions. One car park at the New York World Fair was nearly a mile in length, so that some people would have to walk at least two miles in the process of parking. thus the benefits of using a car are to some extent cancelled out and in such cases public transport has the advantage.

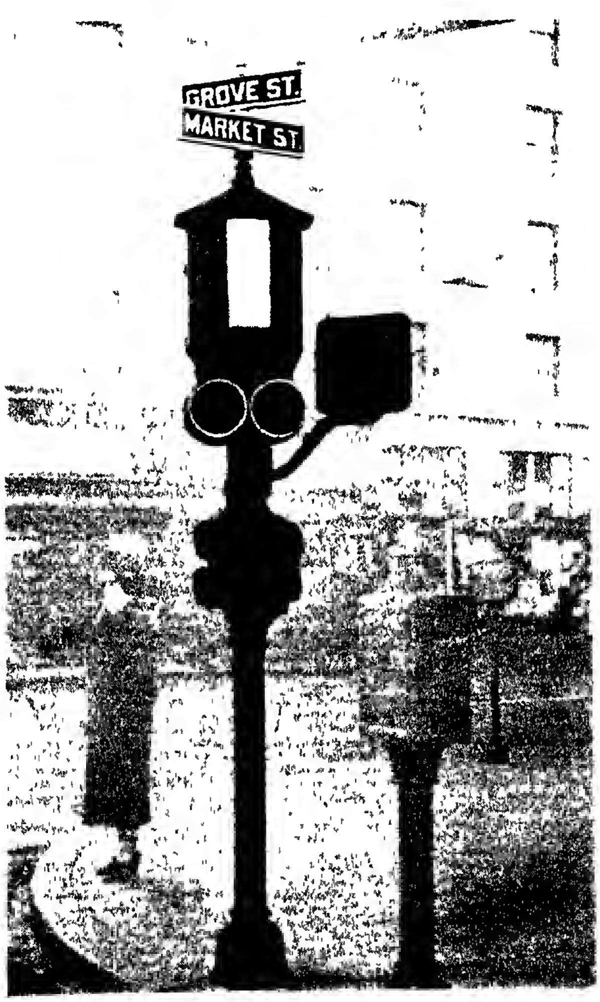


Fig. 6 — Composite Street Sign and Traffic Control Unit in Market Street, San Francisco

BUS SHELTERS

Part of the process of catering for public service vehicles is an adequate supply of bus shelters; these are the equivalent of our railway stations. The correct siting of shelters is an important part of our road planning. The shelters should be placed along straight lengths, a reasonable distance away from corners or junctions, or in some cases on the outer curve at bends; it is essential that the carriageway should be sufficiently wide, or if not, it should be widened, to provide space for standing buses

FIG 7.—BANKING OF CURVE WITH GUARD RAIL TO PROTECT FOOTPATH, TRAFFORD PARK, MANCHESTER

without restricting the carriageway for other traffic, if the footpath is wide enough, bays can be formed to accommodate motor buses

PROVISIONS FOR PEDESTRIANS

Pedestrian Crossings

The time is now approaching for pedestrian crossings to be brought into general use The Ministry of Transport is urging Local Authorities to re-equip these crossings up to pre-war standards The question of the illumination of the Beacons is under consideration but for the moment no decision has been reached If the globes are illuminated then the carriageway stud spacing will be increased in accordance with the recommendation of the Departmental Committee on Traffic Signs

Capacity of Footways

The width of the footway is often restricted by obstructions in the nature of traffic signs, Belisha Beacons, Post Office boxes, etc., which reduce the effective width by about 3 ft. Investigations show that a footway is comfortable for traffic if not more than twenty persons per minute pass along each 2-ft. strip of footpath; a higher density may be allowed for specially busy points or for special occasions.

An example of a composite unit in the main Market Street in San Francisco is shown in Fig 6 This reduces the obstruction to the main footway to a minimum—notice the street names are also embodied, also the pedestrian crossing signs

Guard Rails

At busy points where both pedestrian and vehicular traffic is passing it is recommended that physical barriers may be employed, this, however, should be done with care as guard rails give a feeling of restriction. The openings will obviously be made on to the pedestrian crossings but if foot passengers were compelled to use the crossings within a limited distance thereof, it may be that guard rails could be eliminated. At curves in built-up areas super-elevation can be combined with the erection of guard rails on the outer edge of the curve, thus protecting foot passengers and making safe conditions for road traffic

The roadway on the outer part of the bend may even be raised two or three feet to form a protecting wall to the pedestrians, thus achieving a double purpose (see Fig 7) It may be argued that at slow speeds banking is not so important, on the other hand even a modified super-elevation is helpful to traffic, especially when the surfaces are wet, greasy or frost bound.

PROGRESS IN TRAFFIC CONTROL DEVICES

AUTOMATIC TELEPHONE & ELECTRIC CO., LTD., LONDON, W.C.2

This Company specialize in "*Electromatic*" vehicle-actuated signal equipment, whereby traffic at all types of road junctions can be efficiently controlled. The system normally comprises a Detector, a Controller and the Signals, each of which is described below.

DETECTORS

The Road Vehicle Detector ("Contact-Package" type) is a pressure-operated unit, which is set flush with the road surface, and generally extends over approximately half the width of the road. It is located at a predetermined distance from the road junction, dependent upon the type of thoroughfare and average speed of traffic, but is always fixed so as to afford ample braking time to the average driver, should the signal change to RED as he passes over it.

The unit itself (see Fig. 1) comprises two steel contact strips lying parallel and suitably spaced apart, which, together with their flexible electrical connections are moulded into a rubber envelope. This envelope lies in a shallow cast-iron trough which is concreted into the road, and then surmounted by a hard-wearing rubber tread, which is secured to the trough by steel strips. The envelope excludes moisture and dirt, prevents oxidization and being pressure-operated is unaffected by snow or ice. Where there is any possibility of vehicles passing over it when proceeding *away* from the junction, the uni-directional form of detector is used. In this case the upper steel strip is made in two portions and is designed so that the signals are only operated by vehicles approaching the junction. The "CONTACT-PACKAGE" type is available in nominal lengths of 3 ft., 4 ft., 6 ft., and 8 ft. The 3 ft. and 4 ft. detectors are designed for fixing between tramway lines, the terminal box being located at the side, so as to allow the maximum active service to be used.

THE ROAD VEHICLE DETECTOR ("PNEUMATIC" TYPE) is a recent development and possesses one main advantage over the "contact-package" type, i.e. vehicles "parking" on it do not prevent normal working of the signals. The pneumatic design also permits the contact-making capsules to be so housed that they can readily and quickly be inspected at any time.

In this design (see Fig. 2) the rubber tread has two air ducts extending the full length of the tread, being sealed at the outer end, while the inner end is led out through a rubber tube to a nozzle on the contact-making capsule (see Fig. 3). The capsule unit comprises a diaphragm controlling a pair of "make" contacts, and has two nozzles for connection to the rubber tubes from the air ducts in the tread and the expansion tube respectively.

This detector can be housed in the original castings supplied for the "Contact-package" type, and is available in nominal lengths of 4 ft., 6 ft., and 8 ft., the 4 ft. size being designed for location between tram-lines. All three sizes may be of the ordinary or uni-directional type according to requirements.

THE TRAM DETECTOR is available in a variety of forms to suit all systems of tramway construction. In its general form a circuit is temporarily closed from the live overhead wire as the tram passes, thus actuating a high voltage relay which in turn closes the 12-volt A.C. circuit of the Controller.

One type is suitable for actuation by bow collectors, while that illustrated in Fig. 4 is the type normally used with trolley wheel collectors only. In this case the switch, high voltage fuse and relay are designed for external mounting on a tramway standard.

For conduit tramway systems, a special magnetic form of detector, comprising two units, is available. One of these units, consisting of a special steel cylindrical permanent magnet, is mounted on the off-side of the slot rail. The other contains an armature, contacts and a terminal box, and is mounted on the near-side of the slot-rail. Both units have cylindrical projections which protrude through holes cut in the slot-rails as shown in Fig. 5. Normally, the pull on the armature maintains the contacts open, but when the tram collector remains opposite the pole-face of the permanent magnet, the armature releases, thus closing the contacts.

PEDESTRIAN PRESS-BUTTON.—A typical pedestrian press-button panel is shown in Fig. 6. This is made of cast-aluminium, and the lettering is on a vitreous-enamelled plate.

CONTROLLERS.—All "Electro-matic" controllers comprise a compact, readily replaceable inner unit mounted in a pillar, and fitted with both front and rear doors. The pillar contains the main switch, fuses, a six-way facility switch, a push-button, radio interference suppressor, terminal block, and the permanent wiring. Space is also provided for certain auxiliary apparatus, such as an automatic time switch to switch the signals on or off as required, an electricity consumption meter, mains sealing boxes, etc.

The six-way facility switch and the push-button are fitted at the top of the pillar on opposite sides. This switch can be set in any one of six positions, by means of a special key, without opening either door, to provide the following operations:

Position	*Switch Operation*
OFF	All signal lights off.
AUTO	Signals controlled automatically. Time switch (if fitted) is over-ridden.
AUTO AMBER T.S. CONTROL	Signals controlled automatically and amber globe lights on. Time switch (if fitted) is effective.
AMBER	Amber globe lights only. Time switch (if fitted) is over-ridden.
MANUAL	Manual operation.
ALL RED	All signals display red.

With the facility switch on "manual", the signals can be changed by depressing and releasing the push-button.

In cases where the supply mains are direct current, a second pillar is required, and this contains a rotary converter, together with other auxiliary equipment. The function of the converter is to supply 230 volts single phase at the constant frequency of 50 cycles for the purpose of operating the controller.

THE INNER UNIT.—Several forms of inner unit are available. All units comprise an A.C. operated mechanism which automatically performs the necessary switching operations to the signals in accordance with the indications received from the detectors. Various radial adjustment switches are provided and these enable the controller to be easily and quickly adjusted to the requirements of the traffic at the particular junction at which it is installed.

A chart is attached to the inside of the door and this is suitably marked to show the normal settings. A complete set of drawings and diagrams is also accommodated inside the pillar to facilitate maintenance.

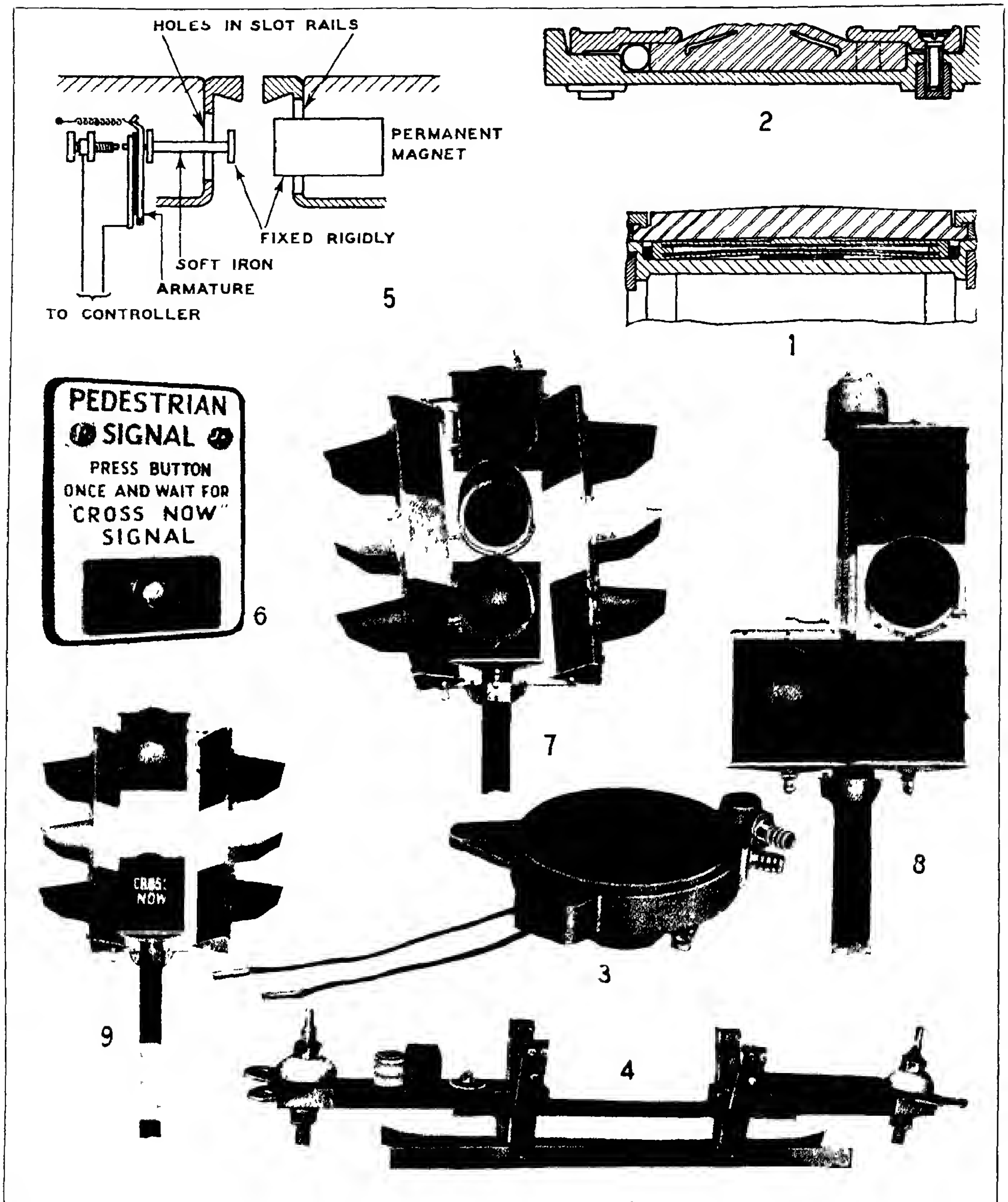


Plate I.—Vehicle Actuated Signal Equipment
Figs 1-9 -Automatic Telephone & Electric Co, Ltd

AUTOMATIC TELEPHONE & ELECTRIC CO., LTD.—(*contd*)

SIGNALS.—Any type of signal lantern may be used with the "Electro-matic" system, and they may be post or bracket mounted or suspended. In the case of A.T.M. control signals, these are built as separate light-weight units which can be fitted by simple attachments to standard, bracket or suspended type mountings. Signal heads are attached by means of laminated springs made of hard-rolled "Staybrite", which greatly facilitates tilting of the heads up or down to ensure maximum visibility on gradients, or where long-range visibility is important.

The optical system of these signals employs an 8-in. chromium-plated copper reflector and a diffusing roundrel which gives good straight-through illumination, combined with brilliant visibility over a wide angle. A typical three-face signal is shown in Fig. 7, while Fig. 8 shows the method of fixing the left-hand turn signal. The single "cross-now" signal shown in Fig. 9 is for use at pedestrian crossings close to road junctions, but a double signal unit for crossings located at some distance from junctions is also available. All wire connections are suitably coloured for identification purposes, and a bare wire is supplied for earthing the signal body.

BARRS-POCHIN PATENTS, LTD., CYFFYLLIOG, Nr. RUTHIN

This company specialize in the production of illuminated road edging, which is available in the following alternative systems, all of which afford drivers sufficient indication of both the width and contour of the road.

SYSTEM A.—This consists of spacing two 1¾-in. diameter reflectors, one white and the other red, back to back at intervals of 4 to 8 yards according to the width of the road, in specially-designed grooves which are carried on to adjacent kerbs (three kerbs in all) to provide free access of light.

SYSTEM B.—This comprises similar spacing to (A), but illumination is obtained by means of a lens holder which carries two wide angle strip lenses, one red and the other white, back to back. The reflectors are not so powerful as in (A), but provide reflection to cars approaching in any direction through an angle of 200°. This system can also be made to give the same colour effect in day-time by the provision of coloured lens holders, the RED, AMBER, GREEN effect being maintained day and night.

SYSTEM C.—In this system, comparatively small lenses are employed (two back to back in each kerb) to provide an unbroken line of illumination.

All three systems provide RED reflectors on the near-side of the road, while the off-side kerb is indicated by WHITE reflectors. Thus a driver can make use of the full width of the road, which is sufficiently clear to him for a distance of 100 yards with only side lights. Pedestrians crossing the road interrupt the reflection, thus indicating their presence. In fog these reflectors, especially in the case of System C, where there is one reflector every 3 ft., are of exceptional value.

FACETED KERBS.—This is a new type of kerb reflector (see Fig. 10) which has been laid experimentally on a strip of road in Somerset.

EXISTING KERBS.—For use on existing kerbs two further types are available. The first, shown in Fig. 11, can be fixed between the joints of kerbs, which should be enlarged so as to accommodate the bolt provided. The bolt is usually grouted in position with cement and the device then secured to it by means of a nut which fits into a recess. The unit is so shaped that vehicles fouling it, "ride-off" the tapered face without causing any damage.

The type shown in Fig. 12 can be fixed to either the top or face of existing kerbs by means of two "Rawlplugs", and can be supplied with either two or four small lenses as required.

In case of the absence of any kerb, the concrete stud shown in Fig. 13 may be used. This is designed to allow for use as a road edging, 2 to 3 in. above and 6 in. below the ground.

B.M.B. ENGINEERING CO., LONDON, W.C.1

Makers of the SAFETI-LINE Road Marker illustrated in Plate III, Fig. 2. This machine has a four-cycle engine with governor control, it does not require a compressor, thereby eliminating many moving parts.

The width of line produced can be instantly varied between 3 and 9 in. and a shielding device ensures sharp definition on the sides of the lines. The spraying attachment can be easily removed and used for spraying gutters, lamp posts, guard rails, etc. The entire mechanism is totally enclosed.

THE CARDIFF FOUNDRY & ENGINEERING CO., LTD., CARDIFF

This Company manufacture flood-lit refuge island bollards and traffic direction posts of varying types for controlling both vehicle and pedestrian traffic. The bollards are equipped for use with either electricity or gas, they are constructed of cruciform section cast iron and weigh from 2 to 3¼ cwt., according to size. Floodlit on all four sides by means of a patented parabolic reflector, they give a down beam of approximately 120 degrees.

This Company also make signs of cast rustless aluminium which can be supplied either plain or reflexed. They can be made with either internal or external lighting.

THE CRUCIBLE STEEL CO., SHEFFIELD, 2

Stainless Steel road-studs and road line plates with fish-tail shanks for grouting in, and drive-in chisel shanks. Made in two sizes, 4-in. square or 4-in. round, for pedestrian crossings and road direction lines.

NORMAN W. DUNN & CO., LTD., DUNNINGTON, YORK

"HAWKINS" PERMANENT TRAFFIC LINE made of white rubber on filled bitumen base. No painting required. Suitable for all kinds of road and traffic direction marking, wording, etc.

THE FIRTH-DERIHON STAMPINGS, LTD., SHEFFIELD

Road marking studs and slabs made in Firth-Vickers "STAYBRITE" steel, drop-forged, solid, square or round heads with various types of shanks. Throughout life they fully retain their silvery-white colour and are guaranteed for 10 years. They are suitable for all kinds of permanent road and traffic direction marking and wording, etc. and require no replacement. Made in various shapes and sizes from 2 in. round to 12 × 6 in. slabs. (See Plate III, Fig. 4.)

THE FOREST CITY ELECTRIC CO., LTD., STRETFORD

This company specialize in the manufacture of Automatic Road Traffic Signals for installation at street intersections, and also Portable Road Signs for use at single-way junctions.

FRANCO TRAFFIC SIGNS, BOREHAM WOOD

Although this Company is only just resuming manufacture, they will shortly be in a position once again to market the well-known Franco Reflex Traffic Signs and Fittings.

GOWSHALL, LTD., LONDON AND WALSALL

All types of road signs, both plain and reflex, and illuminated either externally or internally are manufactured by Gowshall, Ltd.

Their products range from Street Nameplates and Bus Stop Signs, etc., to such items as Portable Warning Signs, Segmented Island Sites, Beacon Globes, Direction Posts, and all types of Road Studs and Letters.

HARDY & PADMORE, LTD., WORCESTER

This firm specialize in the manufacture of street lighting bollards and signs, which are strongly constructed for long life and hard usage.

THE HUB IRONWORKS CO., LTD., CHIPPING NORTON, OXON

All types of road traffic signs.

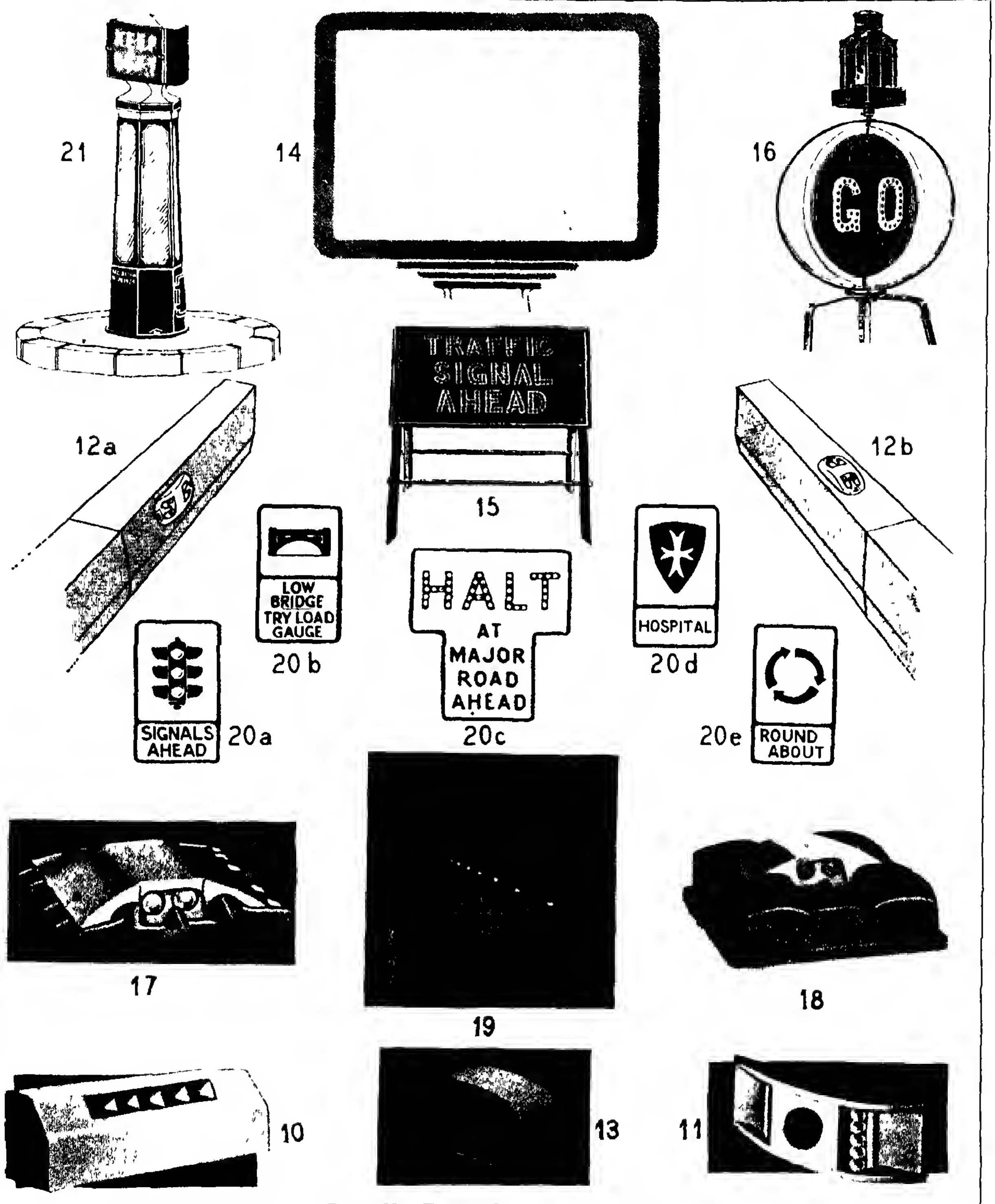


PLATE II.—TRAFFIC CONTROL DEVICES
FIGS 10, 11, 12, 13—BARRS-POCHIN PATENTS, LTD, FIG 14—JESPER, MELLOR & CO, LTD, FIGS. 15 & 16—GEO. PIKE, LTD., FIGS 17, 18, 19, 20—REFLECTING ROAD STUDS, LTD., FIG 21—YORKSHIRE SWITCHGEAR & ENGINEERING CO, LTD

R S., LTD, LONDON, S W 1

This company manufacture a variety of road traffic equipment, some of which is detailed below

ROAD SIGNS—These are made in either cast-iron or aluminium, and are equipped for either internal or external illumination

BELISHA BEACONS—Supplied complete with posts and fittings, the beacons are made from glass or spun 18-gauge steel

ROAD CONTRACTOR SIGNS—These include "Stop and Go" signals, warning boards, etc, and are available with either plain or reflected letters All types are equipped with suitable stands

ROAD STUDS AND WHITE LINE PLATES—The studs are manufactured from stainless steel, and are supplied 4 in square or round, with chisel or fishtail shanks The Line plates, also made of stainless steel, are available in numerous sizes

STREET NAME-PLATES AND HYDRANT PLATES—These are embossed from pure aluminium sheet and finished with cellulose enamels

JESPER, MELLOR & CO, LTD, LEEDS, 11

This Company manufacture all types of illuminated bollard sign panels under the trade name of "*Neolon*" These are so constructed that in the event of damage, the breakage is confined to the plain glass which is fitted to back and front, so that they can be repaired with ordinary plain glass at small cost, while remaining readable until so repaired

Lettering, in which no paint is used, is white on a blue ground, and the sign can be easily fitted to any type of bollard The sign itself is made from non-brittle material, and all glass is sealed with waterproof tape A typical example is shown in Fig 14 *

JOHNSTON BROS (CONTRACTORS), LTD, DAWLEY, SALOP

Makers of simple and effective cornolith island signs and traffic bollards They are easily cleaned, need no painting and are capable of being illuminated by either electricity or gas or can be fitted with reflector studs The signs are in aluminium frames which are easily removed for lamp adjustments

A new development is the LYNX LINE MARKER illustrated in Plate III Figs 3a, *b* and *c*, which eliminates loss of time and liability of error, giving a correct lay-out without marking off It can be folded compactly for transport, and can be used by any lengthman without assistance with the certainty of quick and accurate results

ALEXANDER KENYON & CO, LTD, MANCHESTER

This company is noted for its production of all types of road-workers' tools and also as suppliers of the "*Serilight Lens*" Road Danger Lamp This lamp is specially designed for long-burning without attention, and on 1 gill of paraffin will burn steadily for 50 hours The special "Serilight" lenses fitted provide a brilliant distance danger light, while further luminous lenses in the lamp dome instantly reflect back light from car head-lamps, etc The lamp can be supplied with either three ruby lenses, or white lens and ruby slides, or two ruby and one white lens, as required, and all lenses are easily replaceable if damaged

WALTER MACFARLANE & CO, LTD., GLASGOW, N

All types of traffic bollards

NORTHERN & MIDLAND COUNTIES ROAD SURFACING CO, LTD., YORK

Agents for DURALINE plastic white semi-permanent traffic line, approved by the Ministry of Transport "KARLITE" reflector road studs, which are mushroom-shaped metal studs fitted with powerful lenses and which can be inserted on roads of any type surface This company undertakes the laying of traffic lines and studs under contract to the Highway Authority

GEORGE PIKE, LTD, BIRMINGHAM

This company are pioneers in the manufacture of portable electric traffic controls designed to meet the requirements of Public Works Authorities and Contractors on jobs where some form of signalling other than "flagging" is required (see Fig 1, Plate III) The range covers either or both Hand Operation and Automatic Changeover types, and the controls are designed for use with mains supply or complete with engine-generator set The control panels are fitted with a "tell-tale" arrangement, so that any fault at the signal head is immediately indicated on the control panel

There is also a wide range of warning boards mounted on strong angle iron frames hinged for folding Boards are lettered with reflector studs as required

This firm also supply various other forms of temporary traffic signals and cautionary signs

A typical cautionary sign is shown in Fig 15, and consists of a reflector-type notice board mounted on a strong angle iron frame It is hinged at the top for folding and the letters, which are 4-in in height, are clearly visible both day and night Fig 16 illustrates a typical manually-operated reflector traffic signal, mounted on an iron tripod, and standing approximately 6 ft high The revolving disc is 2 ft in diameter, while the 6-in high letters are coloured RED and GREEN respectively The mounting also provides for the attachment of a red warning light on top if desired

Many other signs are available, and can be supplied with or without reflector studs as desired Various types of paraffin lamps and coloured flags are also supplied The firm are also specialists in the manufacture of all types of Public Authority Tools and Plant

QUEENSBURY ENGINEERING CO, LTD, STANMORE, MIDDLESEX

Manufacturers of illuminated and non-illuminated traffic signs of all kinds for permanent use, in conformity with Ministry of Transport Regulations, and for temporary use during highway construction and repair Products include signs, control devices, reflecting lenses, letters and nameplates in metal, wood and glass

RADIOVISOR PARENT, LTD, LONDON, N W 1

This company is noted for its "RADIOVISOR" Light-Ray Equipment for the automatic control of Street Lamps, Direction Signs, Traffic Bollard Lights, etc, operated on the Selenium Bridge principle The artificial lighting of the signs is automatically switched ON or OFF according to daylight intensity Other productions include general light-ray devices, such as the vehicle counting and vehicle height gauges erected in the Mersey Tunnel

REFLECTING ROAD STUDS, LTD, HALIFAX

This company manufacture a variety of reflecting road-signs, but specialize in the production of a particular road stud, commonly referred to as "CATSEYES" (see Fig 17). The reflecting lenses are housed in a highly resilient bridge-shaped rubber pad which clips into a box-shaped metal base provided with ramps to protect the pad, the complete assembly being paved into the roadway. Vehicles passing over the stud depress the rubber pad containing the lenses and in the process of depression and re-bound, the lenses contact a stationary wiper and are cleaned

The pad comprises a durable rubber unit which is reinforced with canvas on similar lines to a car tyre It is supplied in WHITE rubber, and is easily fixed to the base by means of the special tool provided The lens wiper is incorporated into and forms part of the pad, being firmly secured in a stationary position by the walls of the metal base.

* Since going to press, the colour of all such signs has been changed by Ministry of Transport Regulation to *black* lettering on a white ground.

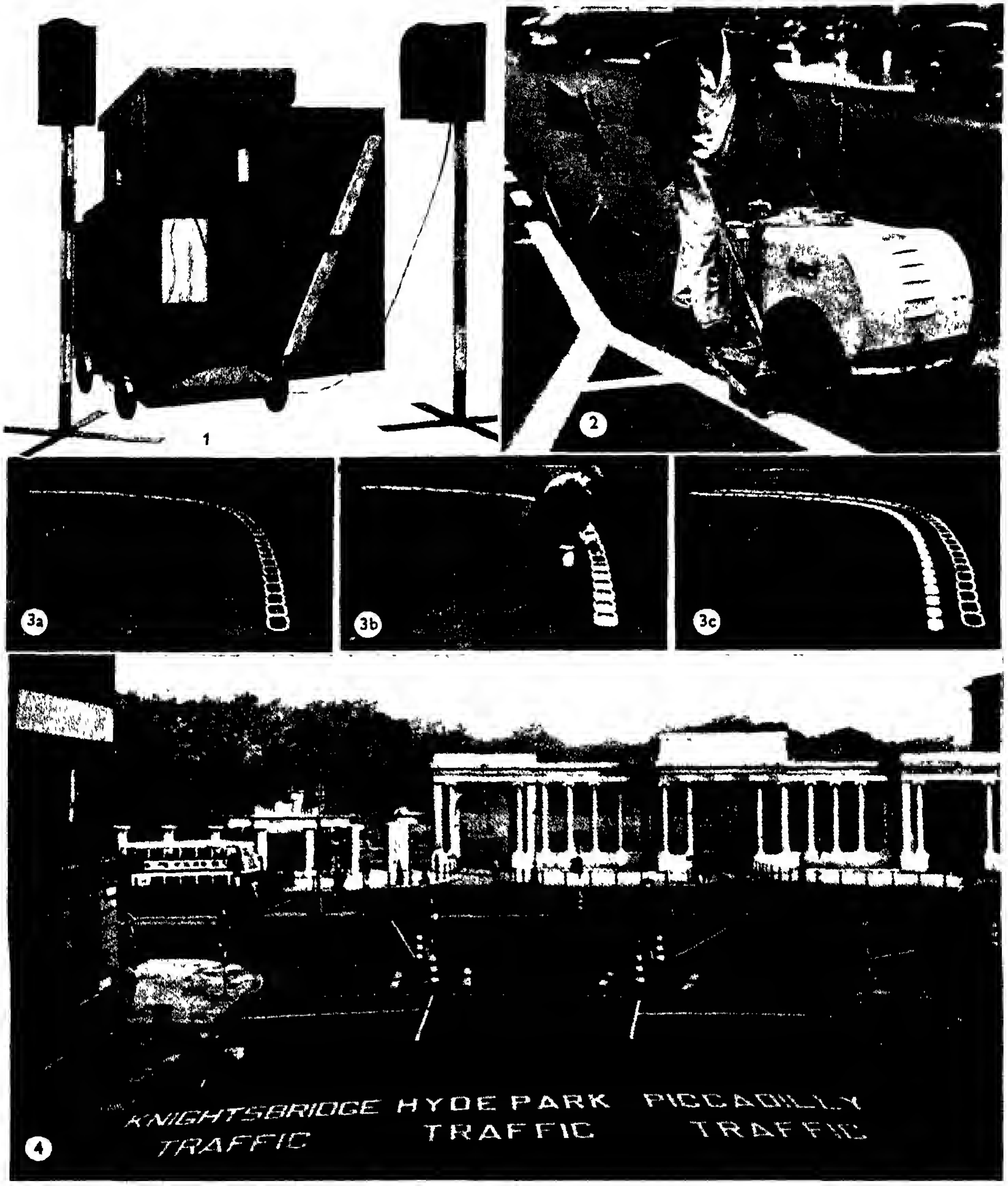


PLATE III.—TRAFFIC CONTROL
FIG. 1.—GEO. PIKE, LTD., FIG. 2.—B.M.B. ENGINEERING., FIG. 3.—JOHNSTON BROTHERS (CONTRACTORS), LTD., FIG. 4.—FIRTH-DERIHON STAMPINGS, LTD.

REFLECTING ROAD STUDS, LTD —(*contd*)

The lenses are each protected in a rubber cap and hermetically sealed in a special copper container They are fixed at a slight angle from the horizontal, so as to give the best reflection at from 70 to 100 yards The lens container is anchored to the pad by means of non-ferrous dowels, two being fitted at each side of the pad Lenses are usually White or crystal, although any special colour, or pads lensed on one side only can also be supplied

The base is cast in one piece and weighs 7¾ lb, and will stand up to heavy army tanks without breaking The raised projection or pad protector ramps afford adequate protection against undue thrust by traffic, snow ploughs, etc Adhesion to the road surface is facilitated by the combination of tapered walls, projecting lips, and particularly by underneath cavities which are filled with the same material as is used for bedding the unit Fig 18 shows the complete unit before fixing

Mastic Asphalt concrete is the medium employed when installing "Cats-eyes"

For the marking of curves with a radius of 200 feet or less, a special angle type stud is available, the opposing pad sides with reflectors embedded, being set at a 10° angle This type is intended for all road bends, Y-junctions, roundabout approaches etc Fig 19 shows a bend provided with this type of stud

Another type is the Kerb Stud, which is a miniature reflecting road stud, complete with self-cleaning device, which can be fixed into any "existing" kerb at varying angles The lenses are kept clean by the rubber pad being depressed by the "occasional" pedestrian

All parts of the "Catseye" road stud are replaceable and the studs, apart from being used to indicate the centre of main roads, can equally well be adapted for Traffic Pens, Road Junctions and Traffic Deviations, also for traffic signs (see Figs 20*a*-20*c*, Plate II)

THE ROYAL LABEL FACTORY, STRATFORD-ON-AVON

All road and traffic signs, street name-plates, hydrant indicators and reflecting road studs cast in silicon aluminium, finished in synthetic enamel baked on Reflex types have high class sealed lenses. All signs are in accordance with Ministry regulations, but special signs are made to order Specially suitable for use in coastal areas where rustless qualities are desirable Lettering is raised above normal surface and is easily renovated

THE SIEMENS & GENERAL ELECTRIC RAILWAY SIGNAL CO, LTD, WEMBLEY

This section would not be complete without some mention of the "AUTOFLEX" system of road traffic signals, installed by the above Company

The system, which is a vehicle-actuated one, employs pneumatic contacts in the road to detect the presence of vehicles It has the approval of the Ministry of Transport, and is available to Highway Authorities responsible for the control of traffic at busy road junctions

Wm. SMITH & SONS, BARNARD CASTLE

This company manufacture Road Direction Sign Posts and Symbols either plain or reflected and constructed from cast-iron or cast aluminium

TARPEN ENGINEERING CO, LTD, LONDON, S W 3

Makers of the TARPEN TRAFFIC LINE MARKER for marking white lines on roads and kerbs, extra equipment can be fitted for spraying beacons and safety fences The machine is operated by a petrol engine and compressor

UNIVERSAL RUBBER PAVIORS, LTD., MANCHESTER

Traffic line blocks and studs made of rubber attached permanently to concrete base blocks, 4½ 4½ in square, they obviate the necessity for repair and are non-skid, dustless, and even-surfaced, absorbing noise and vibration, and have excellent visibility

GEORGE WILD (LONDON), LTD, LONDON, N W 7

Manufacturers of hurricane lanterns for the use of road contractors, etc

YORKSHIRE SWITCHGEAR & ENGINEERING CO, LTD, LEEDS, 6

This company specialize in the manufacture of all types of gas or electrically illuminated refuge bollards

The type C1-FL shown in Fig 21 has a flat lantern with one KEEP LEFT, or other lettered sign and one plain opal glass panel Both panel and sign are fitted in removable metal frames which are locked with special screws for which a key is provided

The trunk of all C-types is fitted with six plain opal glass panels, which cover the major portion of its length, one of the panels being removable Complete electrical equipment (minus lamps) is provided, consisting of Wylex fuse connector and vibration proof lamp holders, while ample space is provided in the lower part of the trunk for housing and time-control mechanism Three ⅝-in foundation bolts are supplied with each bollard for grouting in position on site, or "Foundation Roots" can be supplied if desired, their root depth being 18 in

ACCESSORIES FOR STREET LAY-OUT

DURA FENCING, LTD, LONDON, S W 1

Manufacturers and Specialist Erectors of every type of Fencing.

THE GEO H. GASCOIGNE CO, LTD., READING

This Company specialize in the production of steel clamps used in the construction and erection of traffic signals, etc. Known as "KEE KLAMPS" they consist of a central sleeve with one or more branch sockets, through and into which the constructional tubes are assembled, forming a sliding fit They are gripped in position by cup-sided grub screws which bite into the tube surface Standard bores range from ⅝ in. to 2 in, but other sizes can be supplied Assembly operations are quickly and easily effected, and can be carried out by semi-skilled or even unskilled labour.

HARDY & PADMORE, LTD, WORCESTER

Makers of iron and steel bus queue shelters, of strong construction, as supplied for Worcester, Derby, Chesterfield, etc

HEATHS (ECCLES), LTD, PATRICROFT, LANCS

Well-designed "VICTORY" SEATS made of wood and steel in a good range of sizes for highways and public places

"Q L" TREE GUARDS of wire and steel strips affording ample protection for trees planted in public highways

HILLS (PATENTS), LTD, LONDON, W C 1

Makers of HIGRADE pressed aluminium, and IVORITE riveted on mirror plate background, street name-plates, manufactured by the same method as motor vehicle number plates. The original finish remains permanent. IVORITE lettering is solid white throughout whole thickness.

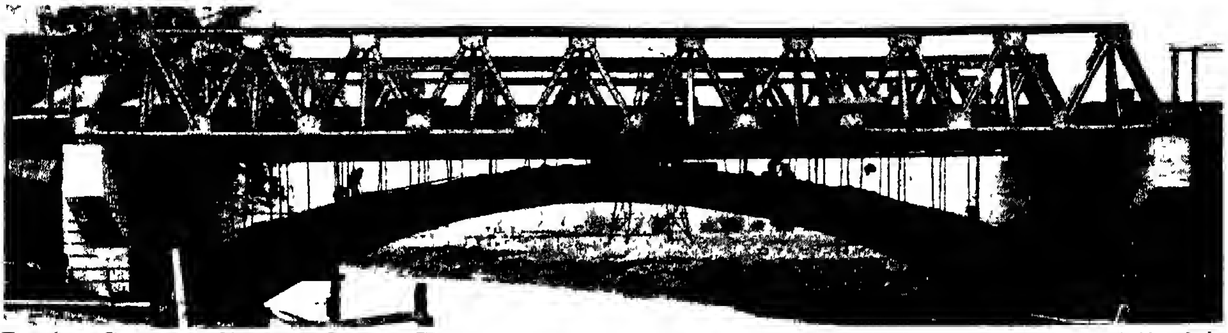


FIG 1*a*—CALLENDER-HAMILTON BRIDGE, GLOUCESTER (*British Insulated Callender's Cables, Ltd*)

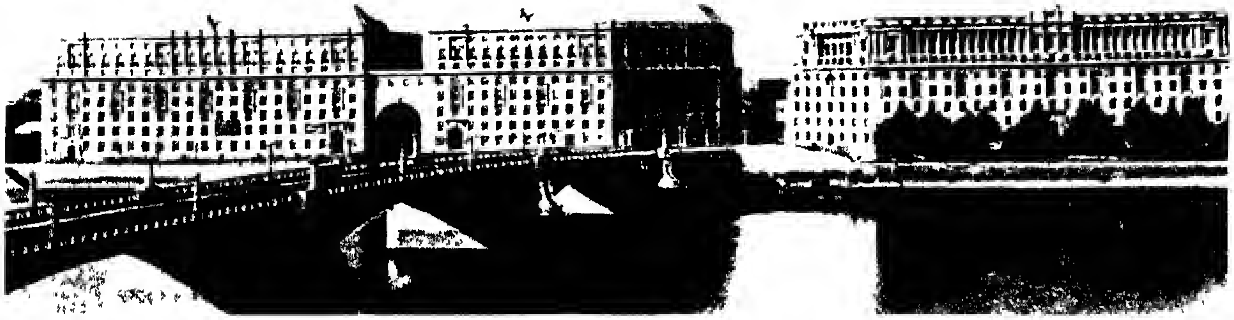


FIG. 1*b*—LAMBETH BRIDGE, LONDON (*Dorman, Long & Co, Ltd*)

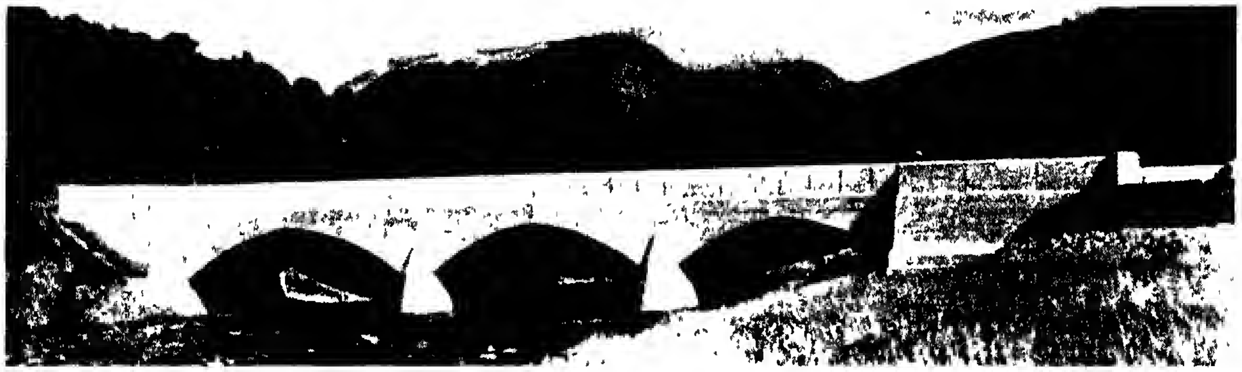


FIG. 1*c* KIOCHNISH BRIDGE, INVERNESS-SHIRE (Engineers, Blyth & Blyth) (*The Ruberoid Co, Ltd*)

FIG 1*d*—LEATHER BRIDGE (Worcestershire County Council) (*The Expanded Metal Co., Ltd.*)

JEPSON & CO., LTD, SHEFFIELD, 1

"DURABLE" street name-plates made of 16 s.w.g. embossed aluminium covered with non-chipping pliable enamel.

PEERLESS FENCE & PRODUCTS, LTD, UXBRIDGE, MIDDLESEX

Manufacturers of lock-woven, chain-link, chestnut pale and woven board fencing, reinforced concrete and steel posts, gates and accessories under the trade name "PEERLESS" Sizes vary according to individual requirements

W. A. SKINNER & CO., LTD, LONG DITTON, SURREY

Specialists in fencing, including chestnut paling, woven board, and wooden fencing of all types. Suppliers also of concrete post and wire fencing and cattle fencing

STEELWAY, LTD, WOLVERHAMPTON

This company specialize in the production of the STEELWAY Pedestrian Safety Barriers. Made from tubular steel, with either one, two, or three lines of railing, these barriers are intended for erection at danger points in roadways, in order to prevent pedestrians stepping off the pavement. The design employs patent sockets, which greatly facilitate the removal of standards or rails, when this becomes necessary

STELCON INDUSTRIAL FLOORS, LTD, LONDON, E.C.4

The STELCON CYCLE BLOCK is made of reinforced concrete with a specially-designed groove to take one wheel of a bicycle. No maintenance is necessary and the blocks cause no obstruction when not in use

A. WEST & PARTNERS, LTD, LONDON, S.W.1

Suppliers of drawing office and surveying equipment of all kinds, specialities include UNO pen stencils with letters varying in height from $\frac{1}{16}$ in. up to 2 in., PLANIFER drawing and tracing papers, sensitized papers and drawing office furniture. RECTOPHAT Rapid Reproducer for photostat copies of plans and documents. This firm undertake plan reproduction, by dyeline, true-to-scale, blue print or bromostat processes, and employ a large staff of draughtsmen, tracers and map and plan mounters

BRIDGES

BRITISH INSULATED CALLENDER'S CABLES, LTD, LONDON, W.C.2

CALLENDER-HAMILTON BRIDGES are unit-construction bridges, which are used as permanent or temporary structures. They are constructed from prefabricated galvanized steel members which have been jig-drilled and are interchangeable, and can be erected with the minimum of skilled labour. After use as temporary structures, they are easily dismantled and the component parts stored without fear of deterioration. There are four types of Callender-Hamilton bridges: A—Light highway foot or cable-carrying bridge with a normal maximum span of 80ft. B (200 ft. span) heavy duty highway and light railway and C and D, railway main and branch lines with 250 and 350 ft. spans respectively

DORMAN LONG & CO., LTD, MIDDLESBOROUGH

This company carry out the construction of steel bridges of all types in any part of the world. A staff of qualified engineers is maintained to produce designs to suit customers' requirements. Fig. 1*b* shows Lambeth Bridge, London

THE EXPANDED METAL CO., LTD, LONDON, S.W.1

"EXPAMET" EXPANDED STEEL-CONCRETE SLABS of uniform thicknesses throughout the cross-section are used as decking of short span bridges to accord with the Ministry of Transport standard loadings for highway bridges. "EXPAMET" EXPANDED STEEL is used to reinforce concrete bridges. Fig. 1*d* shows Leather Bridge built for the Worcestershire County Council with "Expamet" concrete decking and arch

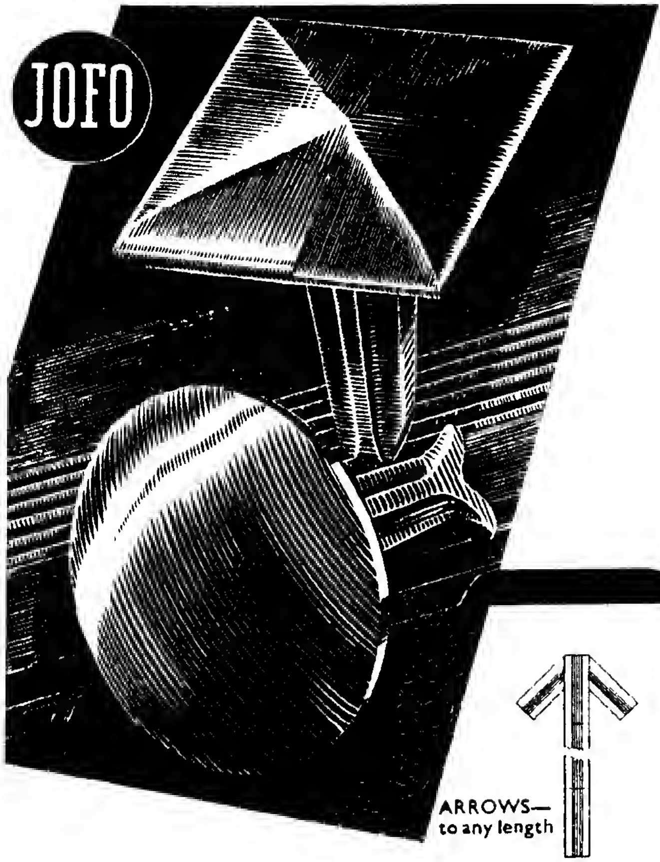
THE RUBEROID CO., LTD, LONDON, W.C.1

PLUVEX bridge insulation is composed of several distinct laminations, each imperishable and waterproof, it is flexible and elastic and its bitumen content is very high. This insulation is equally efficient on bridges of brick, masonry, ferro-concrete or steel. PLUVEX insulation weighs 19½ to 31 lb. per sq. yd., according to specification. On account of its weight it may easily be transported and an outstanding advantage is the speed at which the material may be laid. Kinlochmoidart Bridge, illustrated in Fig. 1*c* is insulated with Pluvex

For Schedule of Paints used in Roadwork, including Traffic Line Marking Paints (see page 236)

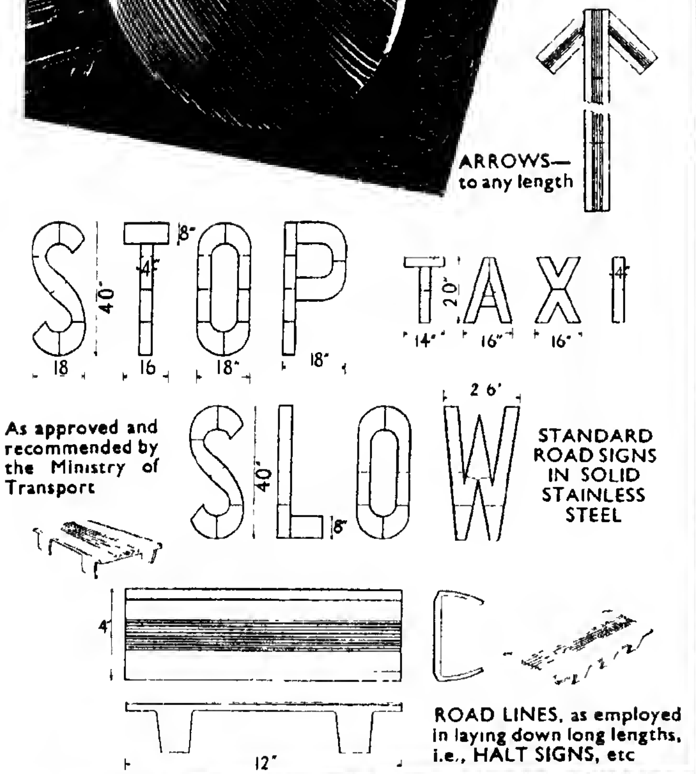
Whilst every care has been taken in compiling this information, the omission of any names must not be held as implying any deficiencies in the products of any company concerned

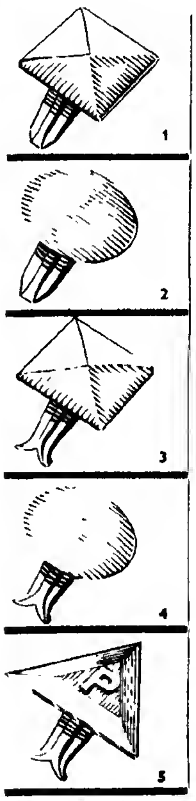
For full addresses, see Manufacturers' Directory



Road
Lines and Studs

★ JOFO Road Studs and Road Lines are supplied in Fine Glazed Finish and are guaranteed for five years. If proved faulty under ordinary working conditions they will be replaced free of charge.





ROAD LINES

Size	Approx Weight	
12″×6″	5 lbs	8 ozs
12″×5″	4 ,,	12 ,,
12″×4″	3 ,,	12 ,,
9″×5″	3 ,,	9 ,,
9″×4″	2 ,,	13 ,,
8″×5″	3 ,,	2 ,,
8″×4″	2 ,,	8 ,,

ROAD STUDS

1 & 2, DRIVE-IN TYPE

Size	Approx Weight
4″ square	17 ozs
4″ round	15 ,,

ROAD STUDS

3 & 4, FISHTAIL TYPE

Size	Approx Weight
4″ square	19 ozs
4″ round	18 ,,

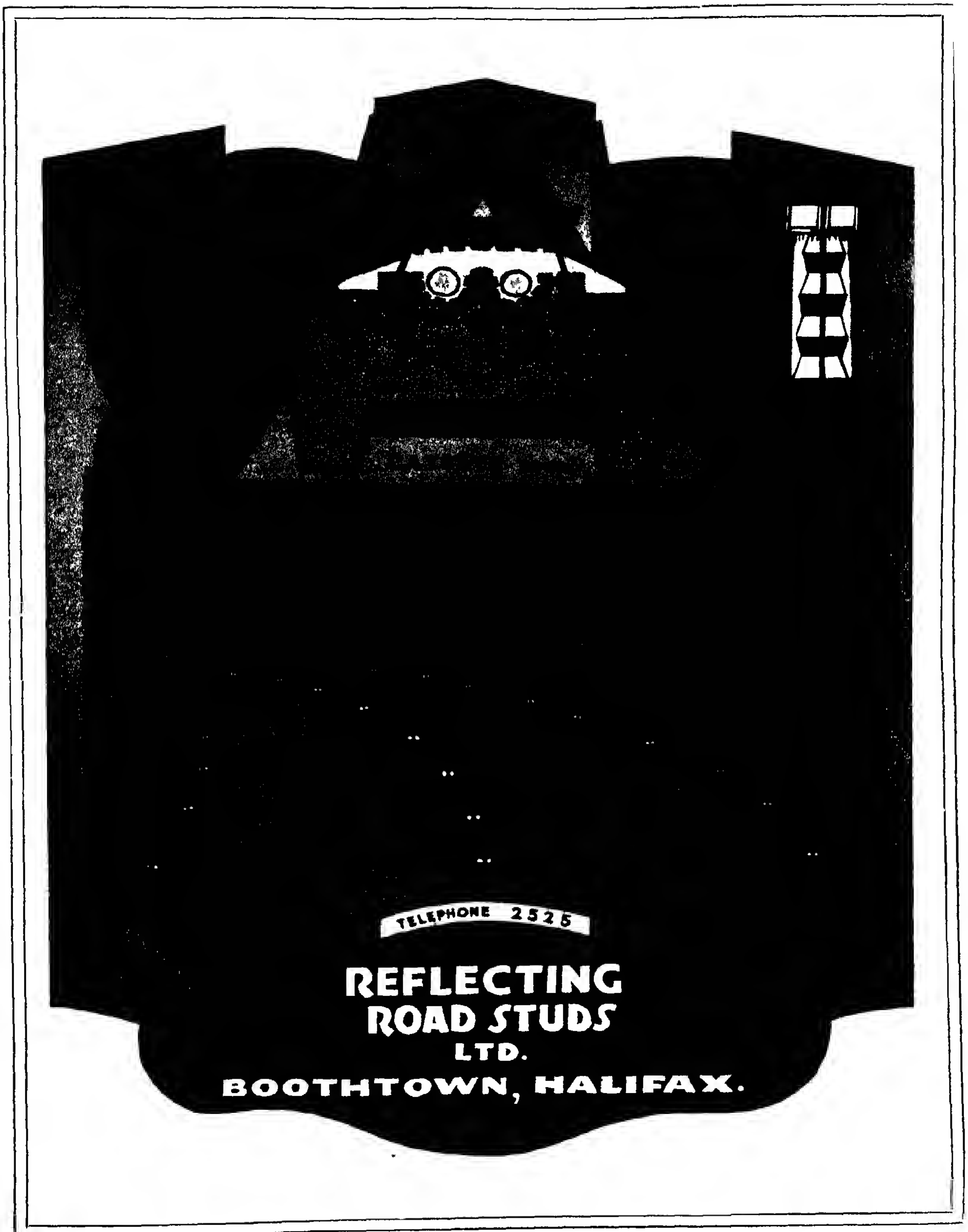
TRIANGULAR PARKING STUDS

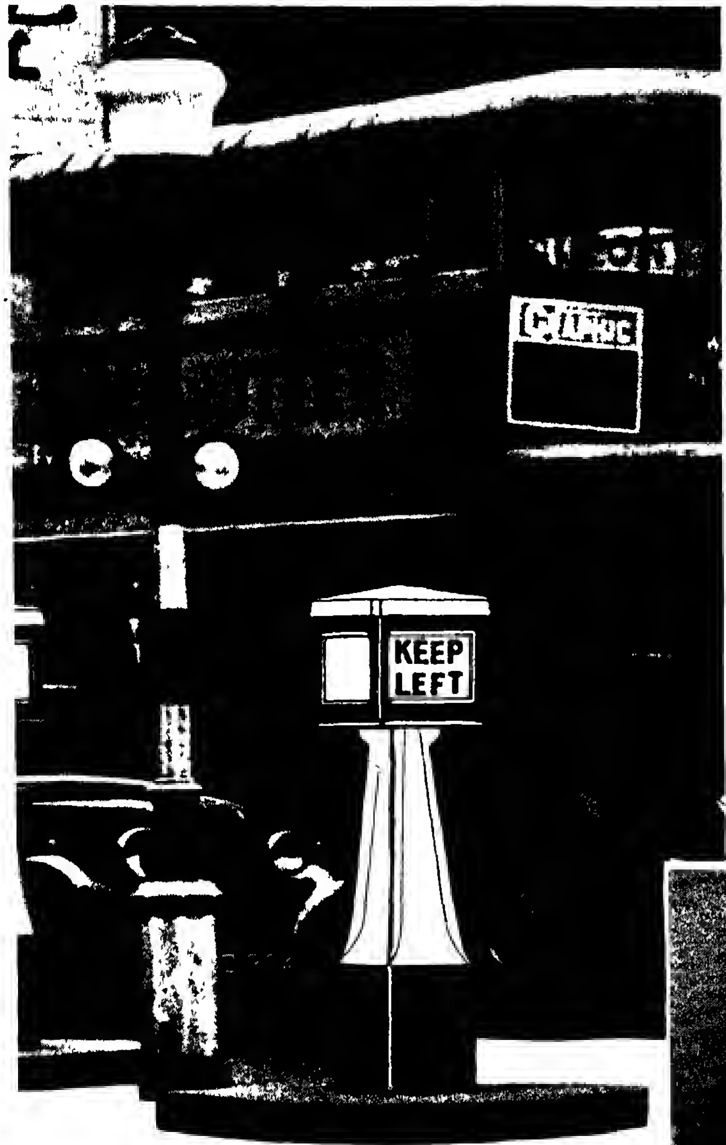
	Approx Weight
5, Fishtail Type	18½ ozs.
& Drive-in Type	18½ ,,

★ Prices for built-up letters will be submitted against enquiries.

OTHER SIZES ALSO SUPPLIED

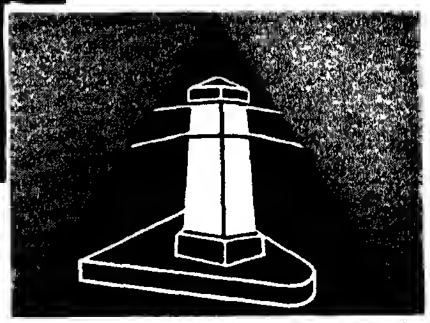
Head Office: BROADFIELD ROAD, SHEFFIELD, 8 *Telephone. SHEFFIELD 52431/4*
London Office: Central House, Upper Woburn Place, London, W.C.1 *Telephone: EUSTON 4086-7*
Glasgow Office: 93 Hope Street, Glasgow, C.2 *Telephone: CENTRAL 4281*


TELEPHONE 2525
REFLECTING
ROAD STUDS
LTD.
BOOTHTOWN, HALIFAX.



In busy congested thoroughfares—in the swirl of heavy traffic—GOWSHALL Signs are clearly seen, day and night, helping to keep things moving smoothly and making a vital contribution to Road Safety

- Internally Illuminated Signs and Guardposts
- Island Sites
- Illuminated Mandatory Signs.
- Direction Signs and Posts.
- Road Signs (illuminated, reflex or plain)
- Portable Warning Signs
- Stainless Steel Road Studs, Lines and Letters



GOWSHALL

AND MEAN WHAT THEY SAY

FOR AUXILIARY TRAFFIC CONTROL

GOWSHALL LIMITED
HEAD OFFICE & WORKS—ST PAUL'S ST, WALSALL (Walsall 4867/8)
LONDON OFFICE & WORKS—LAMB'S CONDUIT PASSAGE, RED LION SQUARE, W C 1 (Chancery 7042 & 7845)

G 4

Section Four

LIGHTING OF STREETS AND ROADS

STREET LIGHTING BY ELECTRICITY

By A D S. ATKINSON, A.M.I.E.E (Lighting Service Bureau)

MODERN street lighting, though mainly designed with a view to the safety of all classes of road users at night, is also valuable in other respects. The police will certainly agree that darkness is one of the criminal's greatest aids, and in well-lighted streets there is far less chance of unlawful interference with people and property Well-lighted streets, shopping areas and open spaces also add to the amenities of any community and proclaim the wish and ability of the local authority to care for the needs of its residents

That street lighting which gives good visibility is a prime factor in reducing road accidents needs no stressing, since those accidents not caused by mechanical failure are mainly due to lack of attention or difficulty in seeing clearly. An obstruction clearly seen in time can probably be avoided, but the time available for seeing is very short and likely to become shorter as traffic speeds increase Difficult seeing is slow seeing, and street lighting which only permits slow vision is of little practical value nowadays

UNORTHODOX SUGGESTIONS

Press articles appear frequently and regularly to advocate this or that new method of lighting streets, which shows a healthy interest in the subject, but unfortunately most of the proposals turn out to be impractical for one reason or another, though they may appear very sensible at first sight

One idea which, in various forms, is mooted periodically is to anchor a balloon and train searchlights onto the underside, or perhaps steam or smoke clouds could be substituted for the balloon. In either case the scheme is that reflected light would be widely distributed—too widely, in fact, for much of it would be wasted on roof-tops and private gardens, and the cost of manpower and apparatus involved would certainly be heavy. Also, what happens on windy or misty nights?

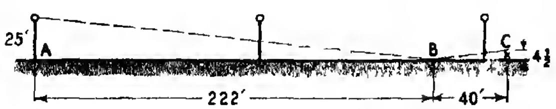


FIG. 1 —LIGHT FROM LANTERN A MAKING ROAD SURFACE BRIGHT AT B

Another scheme frequently advocated is to light streets from the kerb, perhaps by means of lamps behind glass panels in the vertical face of the kerb This has been put to the test and fails on several counts, (1) road camber leaves the crown of the road dark, (2) large numbers of small lamps are required, and both installation and running costs are therefore high, (3) in bad weather, when light is most required, the problem of keeping the panels clean is a difficult one

Generally these unorthodox suggestions show a lack of appreciation of the actual problems involved—problems well understood and already overcome by engineers who have given the subject a great deal of study The best present-day street lighting is similar to that widely used before the war, and is unlikely to undergo any fundamental change for some years at least.

THE AIM OF STREET LIGHTING

Observation will show that, except at short range, people and objects in a street in daytime are usually seen by silhouette vision, that is, they appear relatively dark against the lighter background of the road surface. This of course is partly due to the fact that the road surface is lighted by the whole sky, whereas the vertical surface of an obstruction is only lighted by half the sky Artificial lighting relies upon a series of relatively small "point" sources of light, the positions of which are determined by practical considerations, but the aim is to reproduce natural conditions of seeing as nearly as possible, and to provide a bright road surface against which people and things are seen in silhouette.

Fortunately, the average road surface has peculiarities of reflection which help in this respect, for though dark materials are often used they tend to become highly *specular* (i e. reflecting light in the same manner as a mirror) when light strikes them at glancing angles, while absorbing a greater proportion of the light falling more directly on them.

Thus a motorist (eye level say 4 ft. 6 in above the road) who is interested in a spot on the road

FIG. 2 SHOWING THE T-SHAPE OF THE BRIGHT PATCHES ON THE ROAD SURFACE, THE TAIL OF THE T STRETCHING TOWARDS THE OBSERVER

surface 40 ft ahead of him would see that spot largely because it is made to appear bright by a lamp on a 25 ft standard some 260 ft distant (See Fig 1) There may be, and almost certainly will be, other lamp standards nearer to him, but the technique of modern street lighting is based on the ability of distant lamps to make a road *appear bright* although measurement of the actual *illumination* on the road surface may give very low results indeed Except in special instances, it would be quite uneconomic to attempt to make objects on the road appear brighter than the background, for this would require about ten times as much light.

The general shape of the bright patch caused by a single street lamp usually approximates to a capital **T**, the crosspiece being nearly underneath the lamp, and the tail of the **T** stretching in a long streak towards the observer, the length and breadth of the streak caused by a given type of lantern being dependent on the texture of the road surface, and whether it is wet or dry (See Fig 2)

In a perfect installation, all these patches in the normal field of view of a driver should merge into one another and so give the whole surface of the road an apparently even brightness against which any obstruction will appear dark Economic considerations may indeed limit the degree of perfection obtainable in practice, but the installation should at least be adequate to prevent the formation of dark areas between the patches, for nothing could be more confusing to a road-user than a zebra-like alternation of bright and dark areas through which he is expected to drive safely (See Figs. 3 and 4)

On a straight and level road, with no intersections, the effect desired will be achieved by spacing the lamps at regular intervals, but junctions, cross-roads, curves and roundabouts complicate the issue and may necessitate what at first sight seems an unduly lavish installation.

ELECTRIC STREET LANTERNS

Modern electric street lighting lanterns are of two main types (1) *Cut-off* and (2) *Non cut-off.* The former type is designed so that little or no

light is emitted at angles near the horizontal through the fitting, and there may be a complete cut-off of light down to some 5 degrees below the horizontal. The light is thus thrown more or less directly onto the road surface, necessitating a closer spacing of lanterns than with the non-cut-off type. With the latter, however, distant lanterns appear relatively bright, and may therefore give rise to rather more discomfort

Both types are carefully designed optically, and make use of reflecting or prismatic media to obtain the required distribution of light The optical setting of modern lanterns is permanent, and need not be disturbed when replacing or cleaning lamps Further, there are no products of combustion to foul the interior of the lantern, and cleaning of the lamps and optical surfaces need take place only at long intervals When lanterns are hermetically sealed, as some are nowadays, there is no need to open the lantern until the lamp needs to be replaced.

Nevertheless it would be unreasonable to expect a lantern which is permanently exposed to all kinds of weather to retain its efficiency unless the outside surfaces are cleaned periodically. The prismatic surfaces are normally arranged on the inner side of the glassware, thus presenting a smooth exterior surface less prone to harbour dirt and making the work of the maintenance squad lighter and less frequent

The light output of the lamps and lanterns themselves is virtually independent of weather conditions.

SIDE MOUNTING VERSUS CENTRAL SUSPENSION

The great majority of the roads of this country are lighted by lanterns spaced along the sides of the road, and with adequate siting this arrangement is generally satisfactory since, except on very wide roads, the whole road surface can be made bright without leaving the kerbs and footpaths in comparative darkness Lighting from one side of the road only, however, will be unsatisfactory except on bends, for with the types of lantern most commonly used the far side of the road would be relatively dark.

With side lanterns mounted high and directing their light along the street rather than downwards, it is evident that considerable interference may be experienced from trees bordering the road unless lopping is carried out judiciously and regularly If this cannot be guaranteed there may be no alternative but to use central suspension (See Fig. 5).

With non-cut-off types of lantern, a centrally-suspended system is apt to give a very bright band of light along the centre of the carriageway, while leaving the kerb lines dark, especially in wet weather and on bends This probably results in drivers hugging the crown of the road and risking accident in order to avoid the possibility of collision with pedestrians stepping out from the darker kerbside area With this system it is also difficult to render road junctions conspicuous without additional aids

In comparatively narrow streets fronted by light-coloured buildings which will reflect the light, central suspension may, however, be perfectly satisfactory

GOVERNMENT RECOMMENDATIONS

Every highway engineer should have a copy of the Final Report of the Ministry of Transport Departmental Committee on Street Lighting (August, 1937) for it contains recommendations forming the basis of good modern street lighting practice, and if thoroughly understood will guide engineers to the best lay-out of street lighting for any given circumstances

This Report deals with street lighting under two main headings

Group A—Traffic routes where the standard of lighting should provide an ample margin of safety for all road users without the use of headlights by motor vehicles

Group B—All other routes which the responsible authority considers should be lighted

GROUP A

Mounting Height

The higher a street lantern is mounted, the longer the bright patch seen by the driver will be, and the greater the number of lanterns (and patches) in view on a straight road Thus increasing the mounting height of lanterns makes it easier to arrange for the patches to merge into one another and provide a uniformly bright background, while at the same time it removes near-by lanterns further out of the normal line of vision and thereby tends to reduce glare.

Many existing lanterns are mounted 25–30 ft. high, and it is recommended that in future installations lanterns should be mounted at 25 ft. in order to obtain uniform practice which would be of material benefit to the road user by clearly defining the status of the road.

FIG. 3.—A VERY POOR INSTALLATION WITH EXTENSIVE DARK AREAS ON THE ROAD
A pedestrian, though under the nearest lamp, is practically invisible. Contrast with Fig. 4

FIG. 4.—THE SAME ROAD AS SHOWN IN FIG. 3, BUT RELIGHTED
The bright patches have been merged to form a continuous bright area against which people or objects on the road are seen in silhouette

OVERHANG (GROUP A)

A road width of 30 ft is about the maximum which can be effectively lighted by lanterns mounted vertically above the kerb-line at each side, and for road widths up to 40 ft brackets should be used to overhang the roadway and reduce the distance between rows of lanterns to 30 ft (i e bracket arms would each be 5 ft long in the case of a 40 ft road)

Roads more than 40 ft wide require a line of lanterns vertically above each kerb-line and an additional lantern suspended over the centre of the road at intervals not exceeding every third span (the span or spacing being the horizontal distance measured along the centre-line of the road from one post to the next, whether it be on the same or opposite side) The output of these centrally-suspended lanterns should not be taken into account in calculating the amount of light required per unit length of road

There may be cases in which it is difficult to erect centrally suspended lanterns, though it is desirable where possible to do so. In that case the side lanterns should overhang the kerb by not more than 6 ft in order to avoid unduly dark patches on the kerbs and footways With roads more than 50 ft wide it is virtually impossible to achieve satisfactory brightness of the centre part of the carriageway unless these additional central lanterns are used, and arrangement should therefore be made to provide them even though the expense involved may be considerable

SITING—STRAIGHT ROADS (GROUP A)

On straight roads side-mounted lanterns may be arranged either opposite to each other or in a staggered arrangement The former involves a greater number of lanterns and is therefore likely to give a more evenly bright road surface, but the expense involved is only likely to be justified where a particularly high standard of lighting is required

A staggered arrangement is therefore generally to be preferred, and will give satisfactory results provided that appropriate mounting height, spacing and overhang are adopted

With a 25 ft mounting height and non-cut-off

FIG 5—CENTRAL SUSPENSION OF LANTERNS IN A TREE-LINED ROAD WHERE FOLIAGE WOULD INTERFERE WITH LIGHT FROM A SIDE-MOUNTED SYSTEM

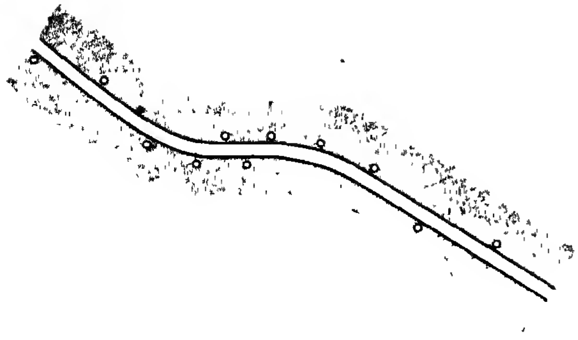


FIG. 6 — STRAIGHTFORWARD STAGGERED SYSTEM GIVING WAY TO SINGLE-SIDED SYSTEM ON BEND

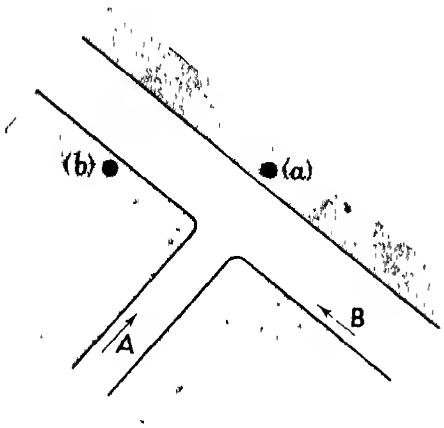


FIG. 7 — SITING OF LANTERNS AT T-JUNCTION

lanterns, the average spacing of lanterns on a straight road should not exceed 150 ft but in order to meet requirements of siting at junctions occasional spans up to 180 ft may be necessary. Where it is economically justifiable, a closer average spacing of 120 ft is desirable. In the case of cut-off lanterns, the average span should not exceed 120 ft.

POWER OF LANTERNS (GROUP A)

Though correct siting is probably more important than any other single factor in the success of street lighting installations, it is evident that satisfactory visibility cannot be achieved without an adequate quantity of light. Roads and road surfaces of such widely different characteristics may be included in Group A, however, that it is impracticable to specify a particular light output as being suitable for all roads in the Group. A range of outputs is therefore suggested, and authorities should choose an appropriate figure within that range, according to the nature of the road and the traffic it has to carry.

It has been found from experience that a light output from the *lamp* of some 4,500–15,000 lumens per 100 ft linear of road satisfies requirements for the various types of road within the Group, but optical control is necessary (according to the type of lamp used) with a consequent loss of light by absorption within the lantern.

The recommendation of the Departmental Committee is therefore that the *lantern* output per 100 ft linear of road should lie between 3,000 lumens and 8,000 lumens, the figures in each case representing the average lantern output throughout the life of the lamp, not initial figures.

Highway engineers should not be misled by claims of exceptionally high luminous efficiency of a particular make or style of street lighting lantern. High luminous efficiency is certainly an advantage if coupled also with appropriate and accurate beam control, but without it the lantern may in fact be less effective than one of lower luminous efficiency.

BENDS (GROUP A)

Since the bright streak on the road surface caused by a single lantern always stretches straight towards the observer it is evident that good visibility requires a lantern to be always dead ahead of a driver, or nearly so, i.e. on a bend with a radius of

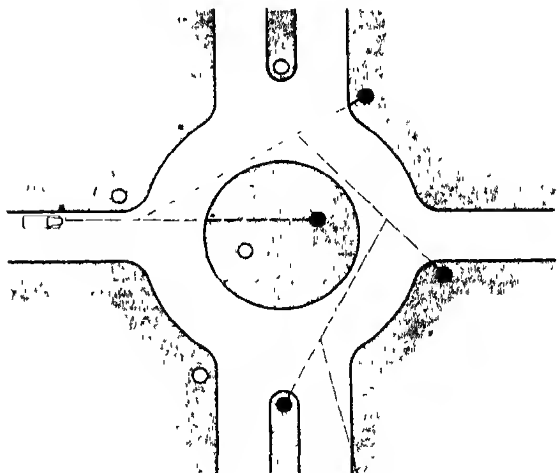


FIG. 8 — APPROXIMATE SIGHT LINES AS INDICATION OF ROUTE

The approximate sight lines for a vehicle turning right are shown dotted, and the lanterns specially important at each stage in this manoeuvre are shown thus ●. The remaining lights shown thus ○ are for traffic taking a different route. Note how the lanterns on the island are each sited opposite the ends of the traffic lanes of two approach roads; it may be necessary to fit opaque screens to the other faces of each of these lanterns in order to prevent confusion.

FIG 9 DUAL-CARRIAGEWAY LIGHTING
Dual-carriageway lighting where each carriageway is treated in the same manner as an ordinary Group A road

less than 2,000 ft a succession of lanterns should be arranged on the outside of the curve On an **S** bend it will be necessary to change the lanterns from one side of the road to the other at some point in the middle of the bend, and it may even be necessary for the lanterns on opposite sides of the road to overlap (See Fig 6)

The spacing of lanterns on bends should of course always be designed to present a continuous bright road surface to the observer whatever his position on the bend, and with a given set of conditions this will depend on the angle subtended at the eye by two adjacent lanterns nearly ahead being less than a certain size (about 7° or less, depending on viewing distance, the type of lantern used and the nature of the road surface)

This principle, adapted as necessary, is also used in the lighting of junctions, crossroads and roundabouts.

T-Junctions and Crossroads (Group A)

Where a side road enters a main road, it is essential to place lanterns in such positions that they will clearly indicate to all road users the presence of the junction and of traffic emerging from or entering it In other words, whichever road a user is on, a bright patch must be provided at the mouth of the junction, and this entails siting a lantern on the far side of the junction from the observer.

A driver proceeding on road **A** towards the junction (Fig 7) must see the end of the road clear of obstruction, therefore a light (**a**) should be placed immediately opposite his traffic lane.

A driver on road **B** must be able to see that there is a junction there, and he therefore requires a lantern (**b**) at a distance up to about 40 ft beyond the junction, while traffic proceeding in the other direction along road **B** will usually be adequately protected by the normal arrangement of lights further along the road.

Thus an intersection of two roads requires four lanterns, one a short distance along each road on the left-hand side in order to draw attention to the crossing and to any obstruction thereon.

Fig. 10—Uni-directional Lighting

Uni-directional lighting of a dual carriageway by which all light on each carriageway is projected towards oncoming traffic, giving a high degree of visibility to drivers without distraction from the lighting for traffic moving in the opposite direction

Roundabouts (Group A)

Here again the aim is to provide an apparently bright road surface to all road users by whichever road they enter or leave the roundabout, and to give them adequate advance indication of the route they have to follow An example of how this may be achieved in a particular case is shown in Fig. 8

DUAL CARRIAGEWAYS

The Ministry of Transport "Memorandum on the Layout and Construction of Roads" states, in effect, that the central reservation should be of the greatest width practicable, and a dimension of 66 ft should be preserved between the outer kerbs Thus a dual 20 ft carriageway would have a central reservation 26 ft wide, reducing to 6 ft in the case of 30 ft wide roads

If the central reservation is wide, each carriageway may be treated separately as if it were a single road, i e staggered lights mounted at 25 ft with an average spacing not exceeding 150 ft and a lantern output of 3,000–8,000 lumens per 100 linear feet

In some cases the two inner rows of lanterns may be mounted on bracket arms attached to a single line of posts Where the reservation is only about 6 ft wide, however, satisfactory results can be obtained by a single line of central lanterns forming a staggered arrangement with the outer lines of lanterns In this case the full power of the central lanterns is taken into account for both carriageways (See Fig 9)

It should be remembered that all the above schemes result in a comparatively large number of lanterns being within the view of drivers, and care should therefore be taken to avoid any features which might confuse them as regards the position of the kerbs and the general direction of the carriageway upon which they are travelling

Dual-carriageway traffic being uni-directional, or nearly so, a novel lighting system tried shortly before the war is of particular interest In this system it was recognized that the portion of the light which is emitted from a lantern in the same

direction as a vehicle is travelling is of very little use to it, but is of considerable value to traffic travelling in the opposite direction Where the traffic flow is uni-directional it should, therefore, be satisfactory to direct all the light from a lantern towards oncoming traffic (See Fig 10)

In practice this system appears to work very well, so far as rather limited experience of it shows A dual carriageway with uni-directional lighting is less confusing to the driver, since he only sees the lights on his own part of the road, the other carriageway appearing dark At least equal visibility can be obtained with some reduction in installation and running cost

TABLE I

SUMMARY OF LIGHTING REQUIREMENTS

	GROUP A (Main Traffic Routes)	*GROUP B (Other Roads)*
Mounting Height	25 ft	13 – 15 ft preferably the latter
Spacing	Non-cut-off fittings 120 ft – 150 ft av Occasional spans up to 180 ft Cut-off fittings 100 ft 120 ft av	Non-cut-off fittings 100 ft — 120 ft av Occasional spans up to 150 ft Cut-off fittings 90 ft 110 ft av
Light output of lanterns per 100 ft linear of road	3,000 – 8 000 lumens	600 2,500 lumens

Adequate visibility must also be provided, of course, in the opposite direction to the traffic flow, in order to provide safe conditions for drivers entering the main road from a side turning, and for pedestrian crossings, but it seems that a well-planned uni-directional lighting system will cater adequately for both main and incidental traffic.

GROUP B

Residential roads are included in this group, and several factors must be taken into account which may not apply so strongly to Group A roads These include the adequate illumination of forecourts and the lower parts of buildings to assist police supervision; particular care to ensure that footways and kerbs are clearly visible, and that shadows unavoidably cast by trees etc. do not fall on the kerbs or roadway; and the appearance of the installation, which should be in keeping with the amenities of the district

It may be assumed that it is economically impossible to light Class B roads to the same high level as the traffic routes included in Class A, and since it is considered desirable to differentiate clearly between traffic routes and other roads it is recommended that both the standard of lighting and the method of installation be changed In some cases it may be doubtful whether a particular road should be included in Group A or B; if so, it will be better to put it in Group A and light it accordingly, than to attempt some lighting scheme halfway between the two classifications, since this would only be likely to confuse drivers unfamiliar with the district

Mounting Height (Group B)

The mounting height provides the most ready means of distinguishing between installations of different standards, and it is therefore recommended that in future installations the upper limit of height should be 15 ft with a lower limit of 13 ft to ensure that the available light is used reasonably effectively and without undue glare

Spacing (Group B)

On straight roads without intersections, the lower mounting will require a closer spacing than on Group A roads If economically possible, a spacing of 100 ft is to be desired, but in any case a general average of not more than 120 ft with a maximum for occasional spans of 150 ft is recommended With the cut-off type of fitting the average spacing should be between 90 ft and 110 ft.

Siting (Group B)

Where there are junctions and intersections the siting of the posts should be settled by following the same general rules as for Group A, but also taking into account the need for adequate illumination of entrances to courts, alleyways, etc. On bends the principle followed for Group A also holds good, but perfection may not be economically obtained owing to the very close spacing sometimes required due to the comparatively low mounting height of lanterns

A staggered installation should be used on straight roads, posts being sited alternately on either side of the road on or near the kerb-line Overhang is of course impracticable where the recommended mounting height is used

Power of Lanterns (Group B)

In practice, limitation of mounting height to 15 ft. also limits the light output of the lantern if

undue glare is to be avoided A range of lantern output from 600 to 2,500 lumens per 100 ft linear of road is recommended, it being left to the authority to choose an appropriate value within this range according to local conditions, e g the lower limit might be suitable for a quiet road in a housing estate, while the upper limit might be required for an apparently similar road which in fact carries a good deal of local vehicular and pedestrian traffic

ARTIFICIAL BACKGROUNDS

In practice the road surface itself does not provide the only background against which obstructions are seen, and a considerable increase in visibility may often be obtained, especially on bends, by allowing light to fall on buildings, hoardings and fences which may border the road, and on vertical surfaces of bridges If, due to a combination of circumstances, good visibility cannot be provided economically in any particular instance by ordinary means, a specially-erected artificial background, maintained light in colour, may offer a satisfactory solution to the problem (See Fig 11)

CENTRALIZED CONTROL OF STREET LIGHTING

Control of street lighting should of course be arranged so that the labour and cost involved is reduced to a minimum, while retaining flexibility to cater for any abnormal conditions that may arise

Individual manual control of the many lamps in the area of one Authority can hardly be considered nowadays, for either a large number of men must be available for this duty, or many of the lamps will have to be switched on well before the appropriate time, with consequent waste of fuel, while others will not be attended to until well after dark ; and the same risk or waste of fuel will occur when switching off in the morning

FIG 11 —ARTIFICIAL BACKGROUNDS
Note how the wall on the outside of the bend provides an additional background against which an obstruction would be clearly visible

Time switches in each electric lamp circuit, or actuating a switch controlling a group of lamps, provide an obvious improvement in service. Time switches have been greatly improved in reliability and utility in recent years, and may now be run for long periods without attention. They need no winding and if fitted with a solar dial automatically make allowance for the changing lighting-up times throughout the year. Certain disadvantages, however, need mention. Normally they are made to operate single lamps or small groups of lamps only, though by the use of additional equipment they could be made to deal with any reasonable load; they cannot be expected to anticipate and correct themselves for the change from B.S.T. to G.M.T. and vice versa, and they operate quite independently of outside conditions, a fact which may not always be agreeable, for in normal times it may be desirable for lamps to be switched on or off according to the amount of daylight actually available at a given time and place, rather than to adhere to lighting-up times calculated with no regard to the state of the weather, and automatically applied by mechanical means.

Photo-Electric Control

Photo-electric control has much to recommend it. When daylight falls below a predetermined value a photo-cell causes the lamps to be switched on, and off again when sufficient daylight is once more available. The sensitivity of the cell can be adjusted so that lights will be on even at mid-day if, say, a dense overhead fog makes it desirable; in fact general experience tends to show that the lamps will be switched on and off rather more frequently than necessary unless sensitivity is deliberately reduced.

Possibly this method has greater advantages in outlying districts than in central areas where there is more provision for responsible human control, but both photo-electric and time-switch control of groups of lamps require either a special set of street lighting mains, or switch wires if the lamps are fed from the ordinary distribution network. If these are not already existing it may be an expensive matter to instal them.

Ripple System

Another general method of centralized control was rapidly coming into use before the war, and is

Table II

ELECTRIC LAMP DATA

The following data apply to first-quality electric lamps of sizes likely to be employed in street lighting. Figures in the column headed "Hours of burning per unit of electricity," include power losses in auxiliary gear, where applicable.

Type	*Nomenclature*	*Wattage*	*Average light output throughout life (lumens)*	*Hours of burning per unit of electricity*
Tungsten filament 230 v	—	100	1,270 (coiled coil)	10·0
,,		150	1,970	6·7
,,	—	200	2,725	5·0
,,	—	300	4,430	3·3
,,	—	500	7,930	2·0
,,	—	750	12,740	1·3
,,	—	1,000	17,800	1·0
,,	—	1,500	28,380	0·7
Mercury	MB/V	80	2,240	11·1
,,	,,	125	3,750	7·3
,,	MA/V	250	7,250	3·8
,,	,,	400	13,600	2·4
Mercury (1) Tungsten	MA/T	300	5,400	3·3
,,	,,	500	10,500	2·0
Fluorescent Mercury	MBF/V	80	2,240	11·1
,,	,,	125	3,750	7·3
,,*	MAF/V	400	12,800	2·4
Sodium	SO/H	45	2,000	16·7
,,	,,	60	3,120	13·3
,,	,,	85	4,850	10·0
,,	,,	140	7,980	6·1

* Isothermal Bulb

Note. 250 watt and 400 watt MA/V type lamps may be used horizontally provided the arc is maintained centrally in the tube by magnetic control, which consumes a few watts. Alternatively type MA/H, specially designed for horizontal burning, may be used without magnetic control, but with some loss of efficiency.

TABLE III

LIGHTING-UP TIMES, GREENWICH, 1946—GREENWICH MEAN TIME

Day	January p.m.	January a.m.	February p.m.	February a.m.	March p.m.	March a.m.	April p.m.	April a.m.	May p.m.	May a.m.	June p.m.	June a.m.
1	4 31	7 36	5 19	7 8	6 9	6 15	7 1	5 6	8 21	3 32	9 6	2 49
3	4 33	7 36	5 22	7 5	6 13	6 10	7 5	5 1	8 24	3 28	9 8	2 47
5	4 35	7 35	5 26	7 2	6 16	6 6	7 8	4 57	8 28	3 24	9 10	2 46
7	4 38	7 35	5 29	6 58	6 20	6 2	7 11	4 52	8 31	3 21	9 12	2 45
9	4 40	7 34	5 33	6 55	6 23	5 57	7 15	4 47	8 34	3 18	9 14	2 44
11	4 43	7 32	5 36	6 52	6 26	5 53	7 18	4 43	8 38	3 14	9 16	2 43
13	4 46	7 31	5 40	6 48	6 30	5 49	7 22	4 38	8 41	3 11	9 17	2 43
15	4 49	7 29	5 44	6 44	6 33	5 44	7 55	4 4	8 44	3 8	9 18	2 42
17	4 52	7 28	5 47	6 40	6 37	5 39	7 59	4 0	8 47	3 5	9 19	2 42
19	4 56	7 26	5 51	6 36	6 40	5 35	8 2	3 55	8 50	3 2	9 20	2 42
21	4 59	7 23	5 55	6 32	6 44	5 30	8 5	3 51	8 53	2 59	9 21	2 42
23	5 2	7 21	5 58	6 28	6 47	5 26	8 9	3 47	8 56	2 57	9 21	2 43
25	5 6	7 18	6 2	6 23	6 50	5 21	8 12	3 43	8 58	2 55	9 21	2 44
27	5 10	7 16	6 6	6 19	6 54	5 16	8 15	3 40	9 1	2 53	9 21	2 45
29	5 13	7 13	—		6 57	5 12	8 18	3 36	9 3	2 51	9 21	2 46
31	5 17	7 10	—	—	7 0	5 8	—	—	9 5	2 49	—	—

Day	July p.m.	July a.m.	August p.m.	August a.m.	September p.m.	September a.m.	October p.m.	October a.m.	November p.m.	November a.m.	December p.m.	December a.m.
1	9 20	2 47	8 49	3 24	7 48	4 13	6 40	5 1	5 4	6 24	4 25	7 14
3	9 20	2 49	8 46	3 27	7 44	4 16	6 35	5 4	5 1	6 27	4 24	7 17
5	9 19	2 50	8 43	3 30	7 39	4 19	6 31	5 37	4 58	6 30	4 23	7 19
7	9 17	2 52	8 39	3 33	7 35	4 23	5 56	5 40	4 54	6 34	4 22	7 21
9	9 16	2 54	8 35	3 36	7 30	4 26	5 52	5 43	4 51	6 38	4 21	7 24
11	9 15	2 56	8 31	3 40	7 25	4 29	5 48	5 47	4 48	6 41	4 21	7 26
13	9 13	2 58	8 28	3 42	7 21	4 32	5 43	5 50	4 45	6 45	4 21	7 27
15	9 11	3 0	8 24	3 46	7 17	4 35	5 39	5 54	4 42	6 48	4 21	7 29
17	9 10	3 3	8 20	3 48	7 12	4 38	5 35	5 57	4 39	6 52	4 22	7 31
19	9 8	3 5	8 16	3 52	7 8	4 41	5 30	6 1	4 37	6 55	4 22	7 32
21	9 5	3 8	8 12	3 55	7 3	4 44	5 26	6 4	4 34	6 58	4 23	7 33
23	9 3	3 10	8 8	3 58	6 58	4 48	5 22	6 8	4 32	7 2	4 24	7 34
25	9 0	3 13	8 4	4 1	6 54	4 51	5 18	6 11	4 30	7 5	4 25	7 35
27	8 57	3 16	7 59	4 5	6 49	4 54	5 14	6 15	4 28	7 8	4 27	7 35
29	8 54	3 19	7 55	4 8	6 44	4 58	5 10	6 19	4 26	7 11	4 28	7 36
31	8 51	3 22	7 51	4 11	—	—	5 6	6 22	—	—	4 30	7 36

When normal Summer Time is in force one hour must be *added* to the above times

(*Reproduced from the "Nautical Almanac" by permission of the Controller of H M Stationery Office.*)

likely to make great strides in the future In this method a high-frequency "ripple" or series of impulses, generated and controlled from some convenient point, is injected into the mains This ripple has no effect whatever on any apparatus not specially tuned to it, but in each lamp standard —or operating the switch controlling each street, group, or area where special street lighting mains are in use—is a relay which responds to the particular frequency of that ripple, and to no other

The various types of "receiving" relay may be tuned to any desired frequency within a given range, and the frequency of the ripple injected into the mains is also variable Thus the street lighting of a whole area, or of individual lamps or groups of lamps may be controlled by push-button operation, all lamps "tuned" to one frequency being affected when that particular frequency is injected.

This system can be applied to all electric street lighting installations, and since the ripples will also pass over high-tension networks, can also be used to control distant areas Electricity authorities are likely to adopt it to an increasing extent, as it can also be used to control other electrical loads, e g off-peak water-heating, with the same equipment but using different frequencies

"D C Bias" System

The "D C bias" system is also successfully used where it is applicable. In most respects it can be made to control electrical load in the same manner as the ripple systems described above, but it is not applicable to areas with Direct Current electricity supply, and for technical reasons a "transmitter" must be fitted at each sub-station Thus it may have a wider application for outlying districts than in more thickly populated areas

EFFECT OF COLOUR AND TEXTURE OF ROAD SURFACE

The optical properties of road surfaces change with use, and a lighting system correctly designed to be satisfactory after a few months' wear may be much less satisfactory when the road is re-surfaced The rate and degree of change vary with the materials used, but are least with stone setts and smooth materials and greatest with asphalt and tar-macadam Even concrete can acquire a marked apparent gloss

When weighing the merits of various road surfacing materials, the highway engineer should not forget the claims of street lighting The use, where possible, of light-coloured materials for surfacing and maintenance will do much to ensure the continued success of a well-planned installation In particular, he should try to avoid the use of materials which become highly specular with wear on the one hand, or have a very dark matt surface on the other, and to maintain the surface as uniform as possible in colour and texture.

ELECTRIC LAMPS FOR STREET LIGHTING

Two main types of electric lamp are in general use for street lighting, and are likely to remain so for a number of years These are.

Tungsten filament gasfilled lamps having the merit of low cost and simplicity, needing no auxiliary equipment except appropriate light-controlling apparatus

Electric discharge lamps which have considerably higher efficiency, but require auxiliary control gear and do not give a "natural" colour of light. This type is sub-divided into·

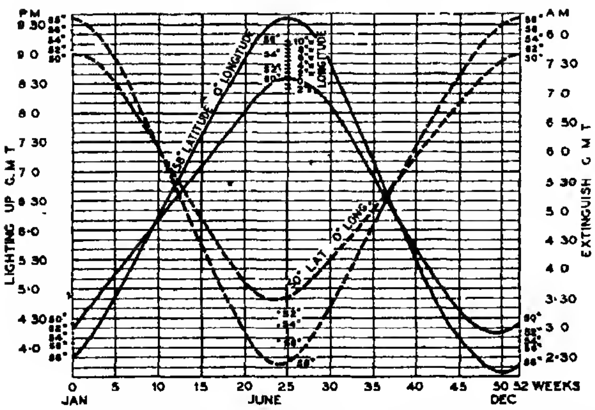


Fig 12.—Lighting-up and Extinguishing Times based on Actual Lighting Requirements throughout the Year

Table IV

NUMBER OF BURNING HOURS FOR 54°N LATITUDE AND 0° LONGITUDE

	Month	Quarter
January	474 0	
February	383 5	
March	359·1	
First Quarter		1,215 6
April	282 5	
May	228 5	
June	184 9	
Second Quarter		695 9
July	208 3	
August	264 5	
September	321 1	
Third Quarter		793 9
October	398 9	
November	443 1	
December	489 8	
Fourth Quarter		1,331 8
Total for Year	4,037 2	

Annual burning hours for other latitudes are approximately as follows

Latitude N	*Burning Hours*
50°	4,080
52°	4,060
56°	4,010
58°	3,980

Mercury lamps giving a bluish-white light.

Sodium lamps giving a yellow light

Mercury/Tungsten lamps (a combination of mercury discharge and filament-type lamps in the same bulb) giving quite a good colour of light.

The question as to which lamp to use is settled more by economics than by anything else, and the answer will depend not only on the cost of lamps and auxiliary gear, where required, but also on the burning hours (all-night, half-night or some other period), the cost of current, and the labour costs involved in lamp replacement and cleaning. The colour of light is of secondary importance to that of ensuring a good standard of safety at the least cost on the rates, and in shopping centres and similar locations where colour distortion might be considered a disadvantage, there is normally more than sufficient light spilled from shop windows, etc. to nullify any distorting effect the street lights may have.

TUBULAR FLUORESCENT LAMPS

The extensive area from which light is emitted by tubular fluorescent lamps makes accurate optical control difficult or impossible, and more than one lamp would have to be used to obtain light output equivalent to that of say, a 250 watt mercury lamp such as is used at present on many highways These factors, coupled with the necessary bulk of any appropriate lantern or reflector, make it improbable that tubular fluorescent lamps will be used to any great extent for general street lighting, though there is every likelihood of their being used in specially selected central areas where aesthetic values may be considered of greater importance than the highest obtainable engineering efficiency In such cases, if used in sufficient profusion, they could indeed turn night into day

HOURS OF LIGHTING PER YEAR

Official "lighting-up times" calculated on a fixed time interval ($\frac{1}{2}$ hour or 1 hour) after sunset may be very desirable for administrative purposes but do not necessarily correspond with the requirements of road users

The period between sunset and the need for street lighting is the time taken for the sun to reach a given angular distance below the horizon, and this varies with latitude and the season of the year Lighting-up and extinguishing times bearing a fixed relation to sunset and sunrise will therefore lead to waste of fuel for lighting at some periods of the year, while at other periods the light will not be there when required

Lighting-up and extinguishing times based on actual lighting requirements throughout the year have been calculated for all latitudes and longitudes covered by the British Isles, the curves in Fig 12 being based on this work * Curves for latitudes between 50°N and 58°N may easily be drawn in, while correction for longitude consists in raising or lowering the entire curves according to the scale shown at top centre.

The hours of use of an installation for all-night street lighting timed as shown in these curves are given in Table IV

BIBLIOGRAPHY

(1) Final Report of the Departmental Committee on Street Lighting, August, 1937 *His Majesty's Stationery Office*

(2) B S 307 (now under revision) *British Standards Institution*

* Association of Public Lighting Engineers 1934.—"A new lighting-up time table based on illumination requirements" by G H Wilson, B Sc , A.M I E E.

STREET LIGHTING BY GAS

By LESLIE T MINCHIN, B Sc, M Inst Gas E, F I.E S

The problems involved in lighting thoroughfares by gas are not essentially different from those involved in lighting by electricity, and in consequence most of the general remarks made in the article on Electric Lighting, page 118, are applicable to either illuminant Street lighting is always a compromise; one could get good results without any difficulty if one had plenty of light, plenty of lamps, and plenty of posts But the areas to be covered by street lighting are so immense and the need for keeping down public expenditure so acute that the question is rather how to get adequate results with the minimum of expenditure

What is "adequate" lighting? Undoubtedly the primary desideratum is that the motorist should be able to see the road in front of him clearly, and distinguish any of the obstacles he has to avoid quickly and easily—especially the cyclist or pedestrian, though it is also very desirable that he should see a dog or a cat in time to obviate that sudden swerve which is potentially dangerous Good visibility for the motorist depends primarily on the creation of a good background for seeing; it should be as bright and as uniform as possible

High average brightness is less important than the avoidance of large dark patches on the road, in which an object may get lost; a vertical dark patch is more dangerous than a horizontal one, since the most important objects to be seen are vertical. In the avoidance of such dark patches the siting of the lamps is the first consideration; there are many cases in the author's experience when half the total light output would have given better visibility had the lamps been sited better. Unfortunately, the surface of the street is not the only background of importance. It has often been pointed out that the pedestrian waiting on the kerb is usually seen against a background in which the road surface plays no part, pavement and buildings are the principle ingredients. If the pavement is tree-shadowed, or if there are no buildings fronting the road, this background may be very dark and a person about to cross the road may be very difficult to see When such a situation occurs, improvement can sometimes be made by the application of white paint to fence or railings, tree-trunks or kerb-stones.

Nevertheless, in spite of this limitation, the street lighting practice of today is largely based on the obtaining of a high surface brightness for the road surface, and there can be little doubt that in a great many cases this approach has been amply justified by results It is of doubtful applicability in the case of very winding roads or roads carrying very dense traffic

The needs of the motorist should not however be allowed to monopolize the attention of the highway engineer, it is also important that the pedestrian's movements should be *facilitated* Kerbs should be clearly visible; road names, house numbers, even bus time-tables need to be legible The police may also legitimately ask that their work be facilitated by the illumination of alleys, front gardens and any other such place where the wrongdoer may lurk Finally, since street lighting is ultimately for the good of the individual, it should be possible for the citizen to recognize passers-by easily, and the general effect should be harmonious and pleasing

THE MECHANISM OF THE GAS LAMP

Although the gas lamp has been used for lighting streets for many years, the principles on which it operates are not well known A full discussion would be out of place here, but the following section covers the most important points which should be known by those handling gas lighting.

(1) The Mantle

The light is actually emitted by a very fine network of thorium and cerium oxides. This *mantle* is the skeleton left behind after the original fabric (usually artificial silk) has been burnt away. Before this the material has been woven from thread and then impregnated with the mixed nitrates of these two elements; on ignition the nitrates decompose to give the respective oxides which are left in a form having almost the same micro-structure as the original fibre. Under the microscope it is at first difficult to believe one is not looking at a textile fabric.

It is partly this fine state of division which

causes the mantle to reach such a high temperature, but the main cause is the peculiar radiating properties of the two oxides. Thoria has a remarkably low emissivity and, because of this, it loses heat very slowly and is able to climb much nearer to the temperature of the flame than would any other substance. By itself it would reach a high temperature (about 2000°K) but give very little light; addition of a very small quantity (up to 1%) of ceria lowers the temperature somewhat but greatly increases the light output. If an attempt is made to go beyond this by adding still more ceria the temperature falls still more and the light diminishes. Too little ceria imparts a bluish colour to the light, whereas too much causes a redder appearance.

(2) The Burner

The mantle is heated by an air-gas flame burning inside it. In the case of a high-pressure lamp the amount of air mixed with the gas before burning is approximately the full amount required for combustion. In the case of low-pressure lighting, however, the proportion is more nearly that found in the domestic gas-ring, viz. just over one-half of the theoretical requirement. The remainder of the air required for combustion flows up around the outside of the mantle where the gases burn in a thin layer just outside the fabric. Normally this layer is only a few millimetres thick, but if the aeration of the burner falls below the optimum this layer will thicken and the mantle will be "left behind" in a less hot part of the flame. This will cause a marked fall in the light output and for this reason the maintenance of a good aeration—as shown by a sharp inner cone when the mantle is removed—is of the utmost importance.

Turning to the other end of the burner, we find that the air is drawn in by a thin stream of gas issuing at high velocity from the injector nipple. This stream imparts its momentum to the surrounding air which is carried forward and is replaced by more air flowing through the air-ports provided. The mixture of air and gas then flows along the burner until it reaches the nozzle inside each mantle. At this point combustion begins, the speed at which the mixture leaves the nozzle being such that flame cannot penetrate into the nozzle mouth. The amount of gas consumed per hour depends almost entirely on the size of the injector nipple orifice and Table I provides a guide to the gas rate to be expected from a given-sized hole. The burner tube and nozzle, together, naturally offer some resistance to the flow of the air-gas mixture and the amount of air entrained is largely governed by this factor. Such resistances may be inherent in the original design—say a sharp elbow or too small a bore burner tube—or may be simply due to accumulation of dust inside the burner. Since the air-gas ratio has such a big effect on light output, lamps should be designed to give the minimum opportunity for dust accumulation and any point at which this may occur should be easily accessible for cleaning.

Another detail which is often the cause of inadequate aeration is the design of the injector nipple itself. Since the whole process of air entrainment depends upon the high velocity of the gas issuing from the orifice, anything which leads to a lower velocity will lower the aeration of the burner. If, for example, the resistance of the gas

Table I

APPROXIMATE GAS RATES OF ORIFICES

Diam. of hole in inches	*Gas Rate at 3 in. pressure (cu. ft./hr at S.T.P.)* Sp. Gr. 0.4	Sp. Gr. 0.5	Sp. Gr. 0.6
0.03	2.7	3.4	2.2
0.04	4.5	4.0	3.7
0.05	7.4	6.6	6.0
0.06	10.6	9.5	8.6
0.07	14.6	13.0	11.9
0.08	19.0	17.0	15.5
0.09	24.5	22.0	20.0
0.10	29.5	26.5	24.0
0.11	36.0	32.0	29.5
0.12	42.5	37.5	34.5
0.13	50.0	41.5	40.5

N.B.—The discharge coefficient has been taken as 0.825

ways leading to the burner is too great, the maker may be tempted to compensate for this by making the injector orifice larger. If this is done, the correct gas rate may be obtained but the pressure immediately behind the injector may for example be only 1 in. instead of 3 in. (water gauge). This would reduce the velocity of the gas jet to some 50°, and a considerably lower aeration would be obtained. Unsatisfactory results are also to be expected if, the pressure behind the injector being normal, the orifice is too large. The fitter will then have to screw the pin well into the orifice to obtain a low enough gas rate, and the effective orifice will be an annulus instead of a circle. This may cause a reduced velocity because of the extra frictional losses involved, or again, it may cause the jet to be unsymmetrical and impinge on the walls of

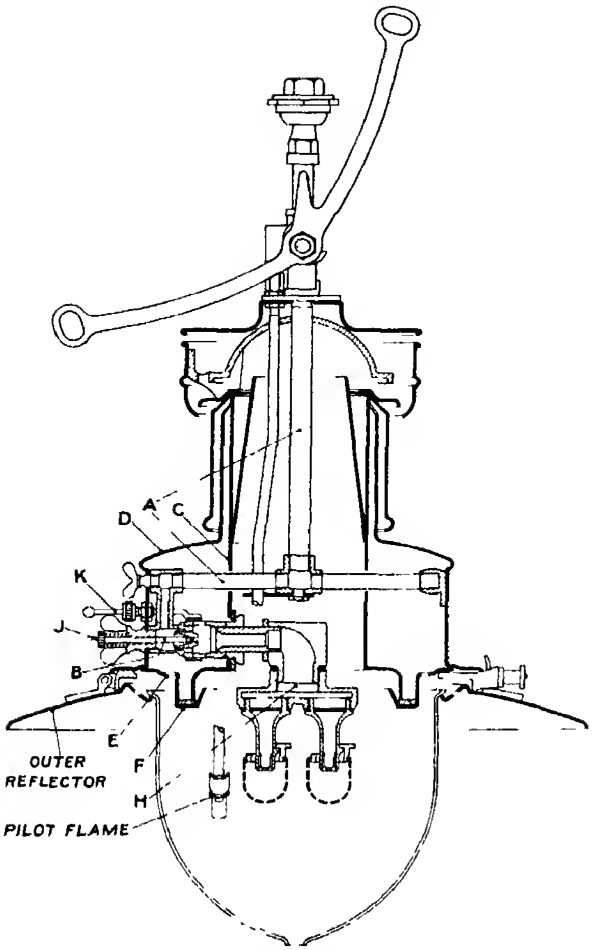


FIG 1 CROSS-SECTION OF TYPICAL SUSPENSION LAMP SHOWING CONSTRUCTION
(*Wm Sugg & Co, Ltd*)

the burner tube; in either case the air entrainment is seriously impaired In general, the use of an injector nipple much in excess of the size given by Table I will not be found satisfactory

(3) THE FLUE-WAY

This serves the very important function of carrying away the burnt gases which might otherwise stray into the primary air chamber. Products of combustion, if they enter the burner, cause an effect indistinguishable from that produced by reduced aeration, i e. the inner cone of the flame lengthens, the mantle becomes dull, and a black spot appears in the centre of the hemispherical portion. Consequently it is absolutely essential that in all lamps no trace of the combustion products shall vitiate the primary air.

The lamp must also be windproof and even a gale must not appreciably alter the air intake, the flue outlet or the circulation of gases inside the lamp. Needless to say it must also be rainproof, and it must be quite impossible for water to collect in the lamp while it is not alight

(4) THE SUPERHEATER

This part of the lamp is not well named, for its primary purpose (at least in low-pressure lamps), is not to pre-heat the gases Primarily it is a distributing head at which the air-gas mixture is sub-divided into a sufficient number of separate streams so that the gas can be burnt on a number of small and robust mantles rather than on one large and necessarily fragile mantle The subdivision also represents a considerable gain in efficiency because.

(*a*) Small mantles usually have a higher luminous output per therm.

(*b*) The inter-radiation between one mantle and its neighbours causes a considerable rise in temperature and with it a marked rise in efficiency. Some experiments made in 1934 ref. (1)* indicated that this increase was about 15%

(*c*) There is a small increase, probably about 5%, due to the pre-heating of the air-gas mixture.

(*d*) The accidental breakage of one mantle does not lead to a complete breakdown, whereas if one large mantle only were employed the lamp would be much more vulnerable

CONSTRUCTION OF A TYPICAL LAMP

Figure 1 shows a cross-section of a type of lamp which is made by most manufacturers It is not a recent design but illustrates the most important features in light production by low-pressure gas The gas enters from pipe A and passes to the injector at B which should be so made that the nipple can be taken out for cleaning or replacement without dismantling the lamp A pin J is usually provided with which the injector orifice can be partly closed, but it is most important that this adjustment should not be used to compensate for too large an orifice In addition an air sleeve attached to the knob K controls the air ports, but in some districts conditions are such that this can be dispensed with At the injector primary air enters from the annular space between the chimney C and the outer case D

* See Bibliography, page 144

TABLE II

APPROXIMATE LUMEN OUTPUT OF LAMPS

Type of Lamp	*Mantles and number used*	*Total lumens per lamp*	*Lumens in lower hemisphere*	*Gas rate (cu ft /hr of 500 c.v.)*
London	12 No 2 B S I	5,100	4,750	30
London	12 No 1 B S I *	4,300	1,000	21
Maxill	12 No 2 B S I	5,360	4,650	30
Maxill	12 No 1 B S I *	4,440	3,750	24
Supervia (high pressure)	1 pouch shaped	7,500	6,900	23
Rochester w/ dish refractor	9 No 2 B S I	4,600	4,100	22½
Folkestone	6 No 2 B S I	2,500	2 500	15
Majestic-multiplane	12 No 2 B S I.	5,000	c. 4,600	30
Maxilla	4 No 2 B S I	2,000	—	10
"8000"	4 No 2 B S I	2,200	1,800	10
Tapered square	4 No 2 B S I.	1 500 1,600	1,300-1,380	10

* *In these cases mantles of longer fabric than British Standard dimensions were used ("long bijou")*

Note—Test figures are quoted here, but significance should not be attached to small differences between one lamp and another It is particularly to be noted that the lumen outputs quoted are for the complete lantern, and no reduction need be made for light losses due to the construction

Air usually enters this chamber by a row of holes at E round the periphery of the inner reflector F The point at which the burner tube passes through the chimney is carefully bushed so that products of combustion cannot leak through The air-gas mixture passes through the "superheater" at H, thence to the nozzles and into the combustion zones The additional air for combustion comes partly from the small hole in the bottom of the globe but mostly from the air inlet round the circumference The products pass up the chimney and through the weather-proof cowl to the air

LIGHT PRODUCTION

The Ministry of Transport Report recommends that the light output of the lamps per 100 linear feet of thoroughfare should lie between 600 to 2,500 lumens for class B roads and 3,000 to 8,000 lumens for class A roads * This method of rating light output has been much criticized in the gas industry because it does not specify the distribution of the light nor even that it must be radiated in the lower hemisphere It is evident that a lumen directed upwards is of less use than a lumen directed downwards and it seems illogical that quantities of light as high as 30% of the total output, which in some electric lamps are radiated in the upper hemisphere, should be credited to the advantage of an installation. It would seem more rational to base the light output of an installation on the light emitted by the lamp in the lower hemisphere only

However, the total luminous output of a gas lamp can be calculated approximately from its heat input Figures published in 1932 (2)† indicate that normal good efficiencies for lamps of the type shown in Fig 1 are as follows:

Using British Standard No 2 mantles ("C") 40,000 lumens per therm

Using British Standard No. 1 mantles ("A") 45,000 lumens per therm

but in comparing this with electric lighting it should be remembered that (*a*) 90% of this light is in the lower hemisphere and (*b*) this is the light output of the complete lantern The lumen output of a number of actual lamps is given in Table II and the efficiency of high-pressure units is discussed more fully in a later section

LIGHT DISTRIBUTION

In street lighting, as in other things, quality is as important as quantity, and quality, in this case, is expressed by the type of light distribution given by the lantern

The Ministry of Transport Report is not able to specify any one type of distribution as being the best in all cases, but it points out the great advantages to be gained from the use of a high candle power at 80-85 degrees from the vertical (often known as "Type 1 distribution").

* See Table I (Street Lighting by Electricity article), page 126.

† See Bibliography, page 144.

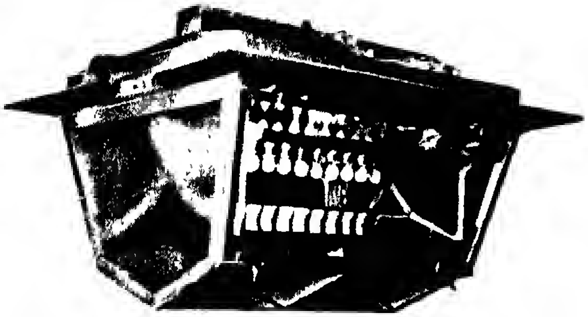


FIG 2 — THE "LONDON" LAMP
(Wm Sugg & Co, Ltd)

The advantage of this lies in the fact that road reflectivity is considerably higher when the light strikes the road at a very acute angle and in consequence, under ideal conditions, a higher background brightness can be obtained if the maximum light is emitted at this angle Furthermore, the light emitted at an acute angle tends to brighten the road surface at some of the points where disturbing dark patches would otherwise occur i e. at the base of the next lamp column

A disadvantage of this type of distribution is that it is almost impossible to avoid some glare, and

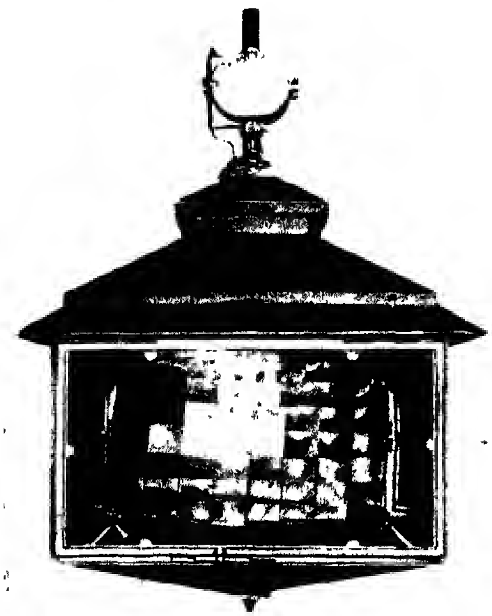


FIG 3 —THE "MAXILL" LAMP
(*Parkinson & Co., Ltd*)

while the tests made by the Departmental Committee did not reveal any serious loss of visual acuity as a result, there is no doubt that there are imponderable fatigue effects associated with this type of lighting Nevertheless, it has been widely adopted and the use of high mountings (25 feet) greatly reduces the glare tendency

There are at least two types of gas lantern designed to give this type of distribution and these are shown in Figs 2 and 3. In the first case the redistribution of the light is obtained by the use of strips of curved mirror glass which are rigidly mounted in a stout brass framework and in the second case light redistribution is obtained by a faceted steel mirror behind each group of mantles Examples of the effect obtained by these lamps when installed are given in Figs 4 and 5

A second type of light distribution is characterized by a maximum candle power in the region of 75° and a sharp reduction to a relatively low candle power above 80° This distribution, often known as "Type 2", greatly reduces the glare and in many cases produces excellent lighting A typical lamp of this kind is shown in Fig. 6. Silvered mirror facets, mounted in a strip on either side of the light source cut off some of the light which would otherwise have been sent out horizontally and reflect this back through the globe at an angle of about 75°.

The disadvantage of this type of distribution is that the light areas formed on the road surface tend to be shorter than if Type 1 distribution is used and in consequence it is desirable, unless the road is very shiny, to mount the lamps rather closer together Good results are obtained with central suspension because, in this case, all the lamps are brought into one line, and in consequence, are twice as close as if a staggered arrangement were adopted. An illustration of this type of lighting is shown in Fig 7

A third type of lighting (Type 3) has its staunch exponents, but it has in the past been used more on the Continent than in England This is the cut-off distribution which emits no light on the horizontal and usually gives a maximum at about 70 degrees This method discards any advantages obtainable by making use of the high reflectivity of the road at glancing incidence, but it has the great advantage that glare is practically absent, and a very soft, restful effect is produced. The spread of the light is, however, greatly reduced, and spacings of 90-100 ft are the most that can be used.

Since with this system the brightness at any one point on the road is due to one lamp only, the

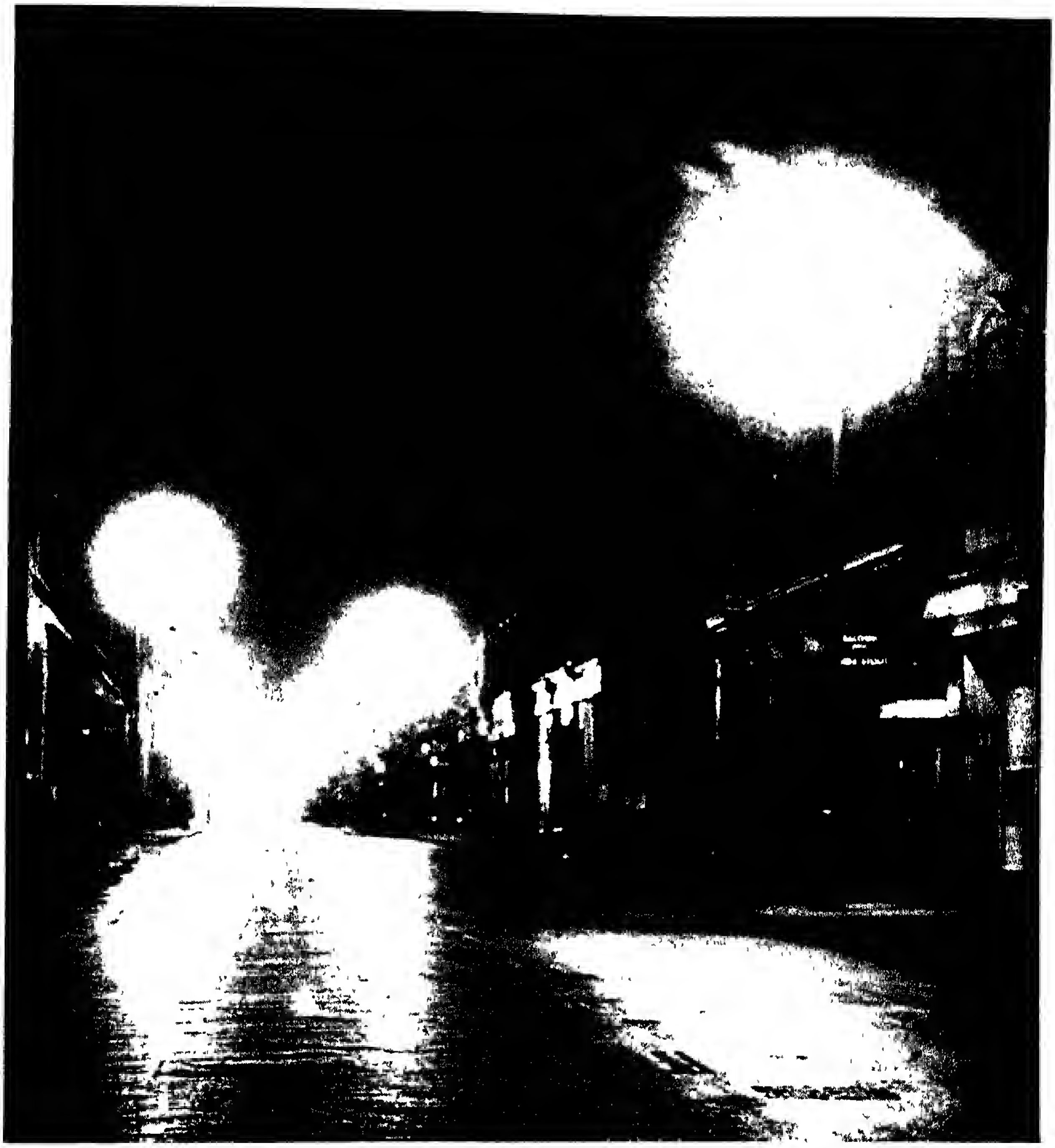


FIG. 4 AN INSTALLATION OF "MAXILL" LAMPS PRAED STREET, LONDON
(*Gas Light & Coke Co*)

lateral spread of the illumination is also important, and this means that unless lamps are mounted in pairs the system is only suited to fairly narrow roads. Central suspension, or staggered with maximum overhang, should be the arrangements used, so that the light patch is spread across the road as far as possible. Only one lamp has been designed so far giving this distribution (Fig 8) but this has already given rise to some excellent installations (Fig 9)

FIG. 5.—INSTALLATION OF "LONDON" LAMPS AT DENTON, CHESHIRE
(*W'm Sugg & Co., Ltd.*)

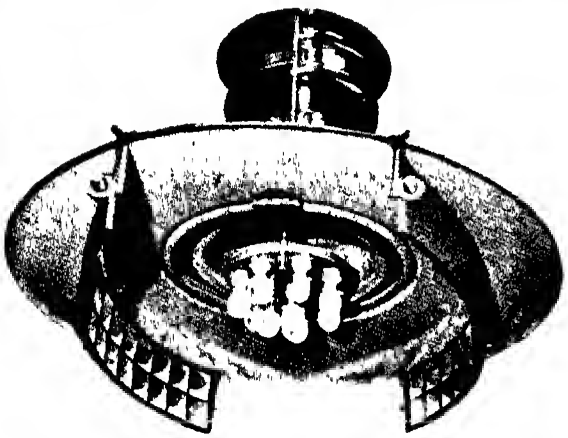


FIG. 6.—THE "MAJESTIC" LAMP WITH MULTIPLANE REFLECTORS
(*Kempton & Son*)

There are, therefore, three types of distribution to choose from; and since, in addition, there are several different ways in which the lamps can be arranged in the street, the number of possible alternatives may appear alarming. In practice, however, if a reasonably good result is to be obtained, the choice is not large, for many of the possible combinations of light distribution-road configuration can be ruled out on the grounds of efficiency; it is also desirable as a rule to keep the number of posts down to a minimum because of the obstruction they cause on the footway.

In 1945, Table III, giving tentative recommendations as to the type of light distribution to be employed under varying circumstances, was put forward by E. S. Harris in conjunction with L. T. Minchin (3).†

This table may be of some use as a guide to good practice but a considerable difference of opinion still exists amongst lighting engineers on this matter. Few roads have a matt surface for much of their life; even concrete becomes moderately shiny when worn. A staggered arrangement is always likely to be more popular than central suspension because of the economy in the number of poles required, so that most installations will come into the two sections marked * in Table III, and for roads of normal width (say 30-40 ft.), types 1 or 2 will normally be used, with a decided preference in current practice for type 1.

METHODS OF RE-DIRECTING LIGHT

The light distribution of a simple mantle cluster mounted in a lamp is shown in Fig. 10, whereas the distribution to be desired for the three types of lighting referred to in the preceding paragraph is shown in Fig. 11. In order to achieve the required distribution, light must be altered in direction. Two physical methods of doing this are available, (*a*) reflection, (*b*) refraction, and both are widely used.

TABLE III

TYPES OF LIGHT DISTRIBUTION

Reflecting Character of Road Surface	*Road Materials likely to have this Character*	*Most suitable type of Light Distribution* — *Staggered Arrangement (roads of moderate width)*	*Staggered (very narrow roads) Central mounting (moderate width)*
Matt	New concrete Sanded tar	2 or 3	2 or 3
Moderate	Macadam Granite setts Wood blocks (esp. if dry)	* 1	2 or 3
Shiny	Macadam (small aggregates) esp. if wet	1 or 2*	2

† See Bibliography, page 144.

Reflection

Reflectors are usually made of stainless steel, chromium plate, or silvered glass The last of these has a much higher reflection factor, is easier to clean, but is usually heavier and more difficult to fix If backed with a lead covering, mirror glass has a good life under suitable conditions, but of course flame must not be allowed to impinge on the glass in the event of a mantle breaking Metal reflectors involve a much higher loss of light by absorption, but on the other hand they are easily fixed and can be taken out for rebuffing or replating when required The use of anodized aluminium has great attractiveness, but it has yet to be shown that the finish is sufficiently resistant to weather conditions and products of combustion

Refraction

Refraction is also widely used, bands and dishes of refracting prismatic glassware have long been used to modify the light distribution from gas lamps of all the older types It is possible for these refractors to be made in two pieces cemented together so that only smooth surfaces are exposed, but unless this feature is incorporated they will need regular and systematic cleaning by a brush or by dipping in hot soapy water at intervals of perhaps a month or six weeks (depending on the locality) if the original light transmission is to be maintained The air of cities deposits a greasy film which is not easily removed by the maintenance man's duster.

HIGH-PRESSURE LIGHTING

This is the term applied to describe lamps made to operate on pressures of 50 - 100 inches of water. At this pressure all the air required for combustion can be entrained and fed through the nozzle at a sufficiently high velocity to prevent lighting back. The mantle is screwed or clipped on to the nozzle so that all the flame gases have to pass through the mantle fabric. By this means a more intense source of light, which operates at a higher luminous efficiency, is obtained. Expressed in lumens per therm, a figure of 70,000 may be obtained under the best conditions, or 55 per cent more than can be obtained with gas at normal district pressure. It cannot be denied, however, that the difficulties of maintaining such a lamp at its full output are greater and in consequence a somewhat larger margin must be allowed between the laboratory figure and street performance

The high-pressure mantle operates at a higher temperature and in consequence there is some deterioration due to the slow volatilization of the ceria. This is dealt with in practice by putting rather more ceria into the original mantle, so that the light output rises during the first few hundred hours of its life, after which it slowly falls again The high nozzle velocity caused the development of mantles much longer in relation to their diameter than is the case with those used in

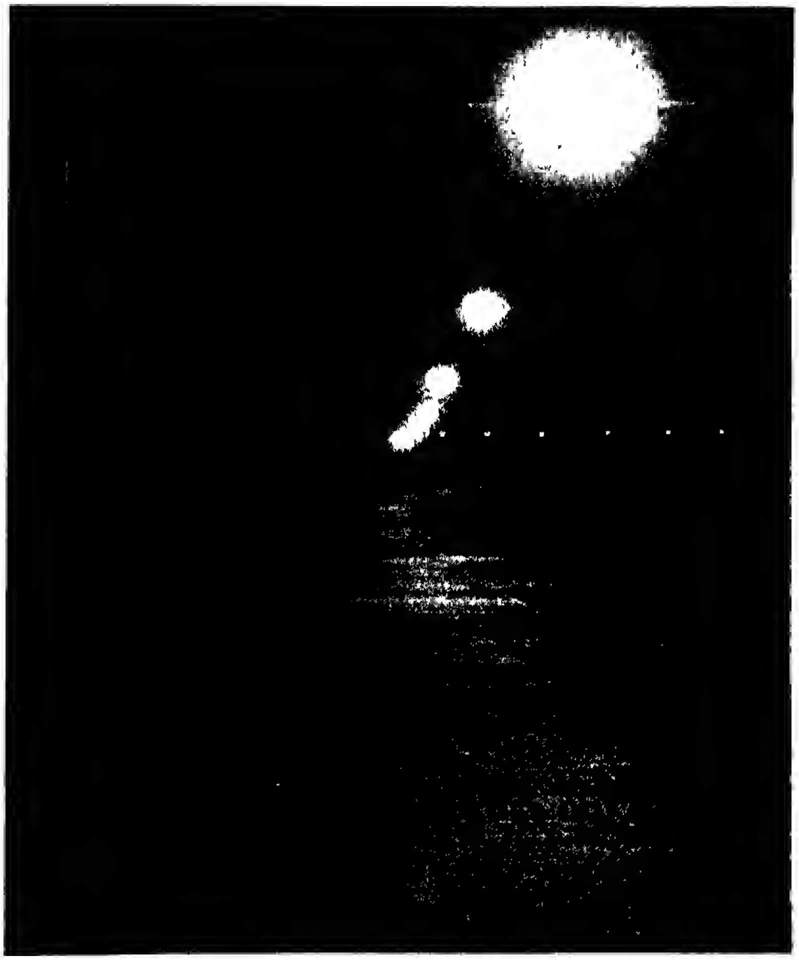


Fig 7 An Installation of "Type 2" Lamps as Shown in Fig 6, at Greenford Road, Brentford

(*Gas Light & Coke Co*)

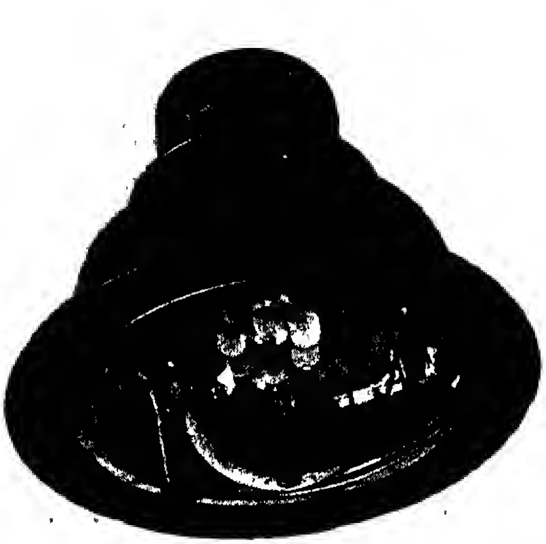


FIG 8.—"THE FOLKESTONE" LAMP, TYPE 3
(Wm Sugg & Co, Ltd)

low-pressure lamps This had advantages from the point of view of light distribution, but was certainly disadvantageous to the mechanical strength of the mantle, and the usual form adopted today is pouch-shaped as shown in Fig 12 This shape also makes control of the light output easier, and the refracting dish below the mantles converts it into a good "type 1" distribution Pouch mantles representing a gas rate of 115 therms/hour (approximately 7,500 lumens) are standard, and lamps fitted with one to three tubular mantles of the older type are also in regular use These are made in three sizes, "500 C P" "1,000 C P" and "1,500 C P." for gas rates of ·05 and ·01 and 15 therms/hour respectively

The question as to whether high or low-pressure lighting should be installed in any one thoroughfare is one which cannot be answered without inquiry into local conditions In some cases the increased efficiency more than offsets the compression charges and increased maintenance costs, in other districts the reverse will be the case

SMALLER LIGHTING UNITS FOR SIDE STREETS

The preceding sections have largely dealt with the lighting of main streets—i e, those coming

FIG 9.—AN INSTALLATION OF "TYPE 3" LAMPS AS SHOWN IN FIG. 8 AT CHERITON GARDENS, FOLKESTONE
(British Gas Council)

TABLE IV

MANTLES USED IN LOW-PRESSURE STREET LIGHTING

No. in B.S. 884	*Name of Mantle*	*Overall height in mm* †		*Inner clearance diam. of ring in mm* †		*Optimum Gas rate* ††
		Maximum	*Minimum*	*Maximum*	*Minimum*	(500 C.F.)
1	"Bijou" or A	33	30	11.8	11.3	1.5
2	"Medium cluster", "No. 2 medium" or C	37	34	15.0	14.5	2.5

† See B.S. 884 for further dimensions and tests

†† See Ref. No. 1 in Bibliography, page 144

within the Class A requirements of the Ministry of Transport Report and having a luminous output of 3,000 to 8,000 lumens per linear foot of road.

The side streets scheduled to have 600-2,500 lumens per linear foot are very important and often neglected. Although this class of road obviously extends to a much greater mileage than the main roads, the scientific problems involved in lighting it have not been studied to anything like the same extent. Clearly, however, the desiderata for street lighting described at the beginning of this article apply with equal force to side streets, though with a certain change of emphasis. Here the motorist has to be considered rather less and the pedestrian and policeman rather more. Here will normally be little or no fast through traffic and a greater need to be able to see kerbs, road names, etc.

This division of roads into "main" and "side" is of course very arbitrary, and a great many thoroughfares might be held to belong to either class. It was, however, the intention of the Ministry of Transport Committee to make this a sharp division and the big difference between the heights of the columns serves to draw attention to it. In practice, however, it is clear that, in districts where the traffic is not very dense, quite important routes will not normally be lighted beyond the Class B standard.

The change of emphasis in the functions of lighting means that the total quantity of light is probably more important and the distribution of it rather less so. In practice, however, it is found that a type 1 or type 2 lamp still gives a much better result than one in which the light is not redirected. Also, although some light above the horizontal is certainly not without its uses, it is still the light emitted in the lower hemisphere which is most important.

TYPES OF LAMPS FOR SIDE STREET LIGHTING

The traditional lamps for this class of work are of course the "tapered square" or "tapered round" lamps. These can give good results on narrow roads, using 15-ft. columns, and they are usually

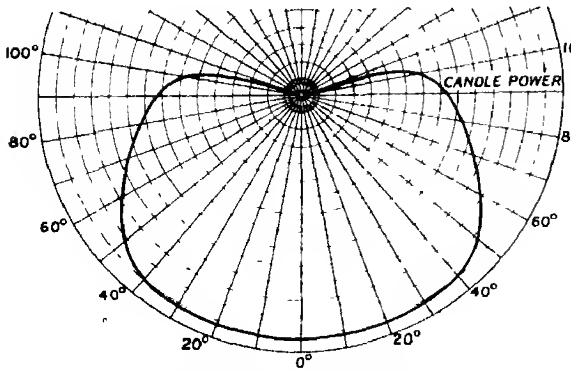


FIG. 10.—POLAR CURVE OF NORMAL SUSPENSION LAMP WITH NO SPECIAL REDIRECTING EQUIPMENT

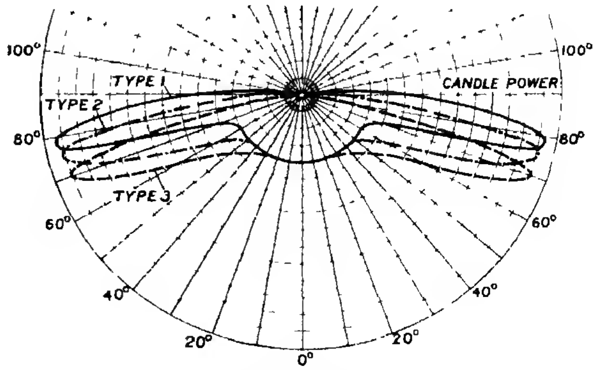


FIG. 11.—POLAR CURVE DESIRED FOR TYPES 1, 2, AND 3 LIGHT DISTRIBUTION

low on maintenance costs, but their appearance is against them and their luminous efficiency is some 15 per cent lower than the figures given on page 135 for more modern lamps

A number of reflecting and refracting devices have been devised to improve the distribution of light from these lamps and have been much used in recent years, but in most districts they are gradually being replaced by newer designs

Figs 13 and 14 show two such lamps primarily intended for side streets The "Maxilla" closely

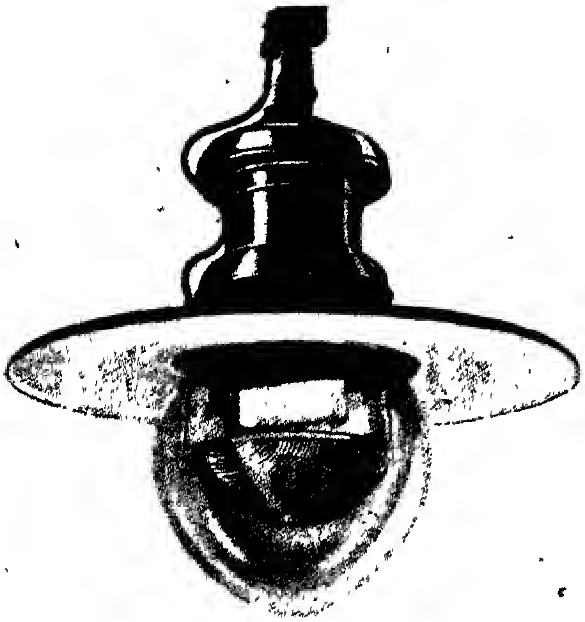


FIG. 12 —THE "SUPERVIA" LAMP
(*South Metropolitan Gas Co*)

resembles the main street lamp shown in Fig. 3 The desired light distribution is obtained by a faceted aluminium mirror.

The lamp shown in Fig 14 collects some of the light going into the upper hemisphere and sends it into a beam which is usually set at 80° to the vertical and which can be adjusted azimuthally to deal with bends in the road. This is important, as side roads are apt to have very sharp bends, and it is not an uncommon sight for a lamp to be situated on the outside of a bend, with its main beam projecting into a back garden or on to a brick wall It should, of course, be directed along the kerb. A three-way pattern for T-junctions is also available.

CONTROLS

Modern practice has progressed a long way from the days when the lamplighter plodded round the streets lighting lamps with a tongue of flame emitted by a spirit-torch In practically all modern installations lamps are clock-controlled and the permanent pilot-flame is fast disappearing in favour of a battery-ignited pilot system

The higher mounting-heights now usual, combined with the greater use of suspension lamps have made the base of the column the most convenient position for the clock; this, however, is only possible if some means is provided for closing the pipeline at the end nearest the lamp while the lamp is not in use and diverting all of the small amount of gas still passing into the pilot flame. This requires a simple valve known as a *distant control valve* which closes the gasway completely when the pressure falls below a given amount (1½ in), and thus diverts the remaining trickle of gas into the pilot In the case of high-pressure gas a further modification is necessary, in view of the big difference between full-on pressure and by-pass pressure. This would naturally result in a very big by-pass flame when the lamp is alight and so a slow-acting valve is incorporated to shut down the pilot when the main gas stream is flowing.

ELECTRIC PILOT

The electrically ignited pilot is a further complication but one which is usually thought well worth while because it abolishes the need to keep a pilot flame burning during the whole time when the lamp is not in use. This not only results in a saving of gas which soon pays for the increased cost of the equipment, but actually gives a more reliable service A lamp will normally be "on by-pass" for a longer period than it is alight, and extinction of the pilot flame whether by draught or blockage at any one moment during this time will prevent the lamp from lighting when the clock next switches on. With the electrical system the pilot is only alight for perhaps a few minutes each day The current is provided by either a 1½ or a 3 volt battery housed in or above the lantern; an electrical contact in the valve mechanism causes a small coil of platinum wire to be heated and thereby ignite the pilot flame as the main gas stream is turned on, and after a short interval of time the pilot gas is turned off again. The scheme is shown diagrammatically in Fig. 15.

The gas enters from the connexion on the right-hand side when the clock turns on the gas cock. This one would expect to cause the upper of the two diaphragms to rise immediately but the movement is spread over a period of minutes by means of a slow air leak from the space above it through the "Time Control Adjustment."

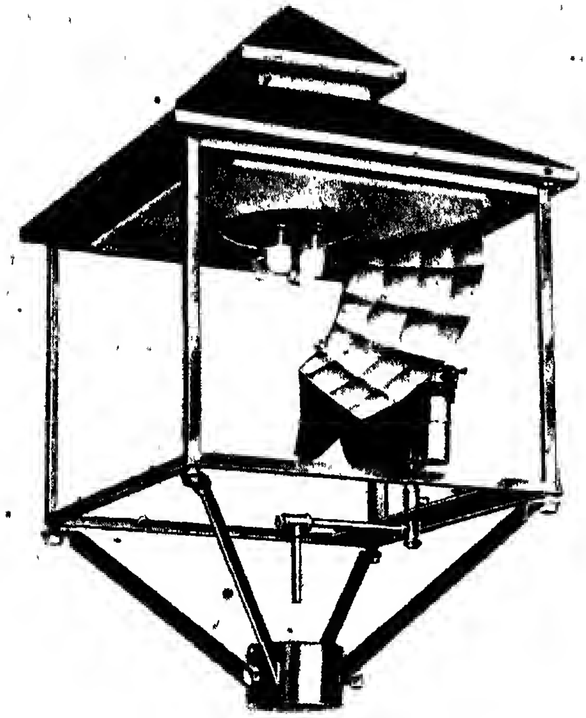


Fig. 13.—The "Maxilla" Lamp
(Parkinson & Son)

Fig. 14.—The "8000" Lamp
(Wm. Sugg & Co., Ltd.)

The first effect of the slow rise is to open the valve and admit gas into the lower compartment. This has the effect not only of admitting gas to the pilot but also of causing the lower diaphragm to be depressed so that electric contact is made which energizes the platinum wire in the pilot head. When the upper diaphragm has risen to the top of its travel, the central valve is again closed and both the by-pass and the electric current are turned off.

MAINTENANCE

No installation will be satisfactory unless adequately maintained, and the fact that a gas lamp requires, as a rule, somewhat more attention than an electric lamp often means that a more uniform output can be obtained under service conditions. Some figures quoted just before the war (4)* showed that weekly illumination readings on one particular installation only varied between 88 and 110 per cent of the rated value over a period of twelve months.

The draft B.S. Specification on Street Lighting circulated in the Autumn of 1935 (CH-ELG-1524) contained a clause specifying that the candle power of the lamps should not drop below 50 per cent of the initial figure—or some higher percentage to be agreed upon between the parties. There must be many gas undertakings who would be willing to accept such a higher percentage, since the amount of inspection normally given to a gas-lighting installation in a well-run concern ought to keep the light output within 75 per cent of its rated value. In any case, the visibility obtained in practice is obviously more important than the result obtained on the first night, and any highway engineer would be wise in obtaining some guarantee as to the maintenance level to be worked to, whatever the illuminant.

It should be remembered that the adjustment of refractors or reflectors is a very important factor as well as the total light output, and the test to assess maintenance should therefore be taken if possible in or near the direction of maximum candle power. Probably the test given in the draft B.S. Specification is the most convenient way of doing this. Briefly, it consists of measuring the illumination on a vertical plane three feet above

* See Bibliography, page 144

the kerb and one span distant from the nearest lamp. The figure obtained is multiplied by the square of the distance in feet to the foot of the nearest column. This is a relatively simple test which will indicate if the installation is in good order, though it would be foolish to pretend that it could never give misleading results if relied upon uncritically

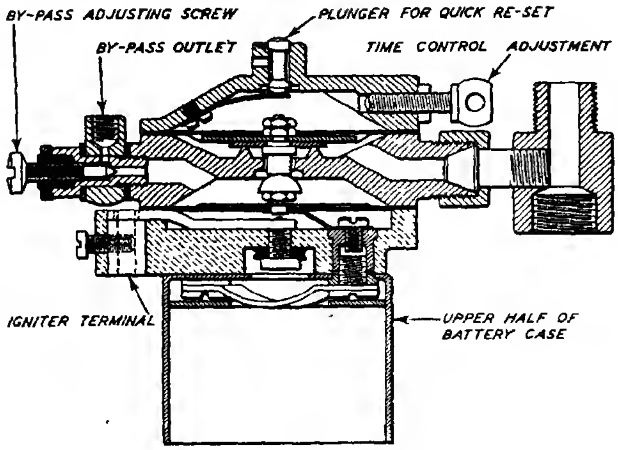


FIG. 15.—DIAGRAM OF THE "COMET" IGNITER
(*Horstmann Gear Co., Ltd.*)

CONCLUSION

The long period of war has imposed a strain on all those who design, construct, install and maintain gas lamps, from which they have not yet fully recovered. At the time of writing, for instance, the post-war fuel shortage is imposing economies which go far to ruin many a well-planned installation. Under these conditions it is not easy to forecast the future, but if, as seems likely, the amount of ingenuity and enthusiasm which gas lighting excited before the war returns under full peacetime conditions, there can be little doubt that gas lighting will continue to play a very important role in the lighting of our streets

BIBLIOGRAPHY

1 "*Principles of Gas Lamp Design*," L. T. Minchin, Proc. Jun. Gas Assoc. **24**, 305 (1934)

2 "*The Planning of Gas Installations*," F. C. Smith, Institution of Gas Engineers, Pub. No. 54 (1932)

3 "*The Commercial Aspect of Public Lighting*," E. S. Harris, Association of Public Lighting Engineers, 1945

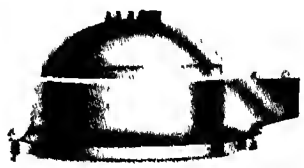
4 "*Light on the Roads*," British Commercial Gas Association

ELECTRIC LIGHTING

THE BRITISH THOMSON-HOUSTON CO., LTD., LONDON, W.C.2

The period of intensive research on street lighting problems which started with the end of the war has resulted in the production of some entirely new lanterns by the British Thomson-Houston Co., Ltd.

THE MAZDALUX STYLIZED RANGE OF SIDE-ENTRY LANTERNS
A new series of Mazdalux Side-Entry lanterns has been designed to meet the demand for a complete range of lanterns accommodating every type and size of vertically operated Mazda and Mercra street-lighting lamp. This new "Stylized" range consists of sixteen lanterns and, for the first time, lanterns with a uniform appearance can be installed throughout an entire city and on all the roads leading to it. The varied requirements of such locations as shopping centres, side streets and car parks are all catered for in difference of size, glassware and types of lamp. The shape and appearance of the lantern have been carefully designed to blend well with all types of surroundings and to match both steel and concrete standards.



MAZDALUX SIDE ENTRY

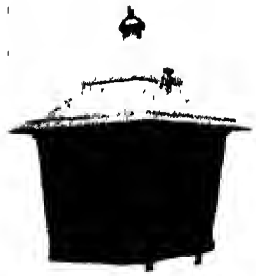
THE MAZDALUX HORIZONTAL ENCLOSED LANTERN. This is another street lighting lantern which is the product of past experience and recent research. The main features of this new lantern are a first-class optical performance and fine appearance combined with very simple erection and maintenance. Magnetic arc control enables the standard type of vertical-burning Mercra lamp to be used in a horizontal position. The well-known BTH principle of controlled cut-off is employed to give constant visual accommodation and a minimum of glare. This allied to the horizontal light source, gives the maximum continuity of road brightness and optimum seeing conditions.

MAZDALUX HORIZONTAL

FLUORESCENT STREET LIGHTING.—The British Thomson-Houston Co., Ltd. is also experimenting with an entirely new form of street lighting. Mazda 5-ft 80-watt fluorescent lamps in specially-designed lanterns have been used for experimental street lighting installations with most encouraging results.
Noteworthy features of the new lighting are its remarkable freedom from glare and its specially pleasing character which does not distort natural colours.
The lanterns can be conveniently suspended on wires stretching across the street between buildings, and street standards, which are undesirable obstacles on busy pavements, can in many cases be dispensed with.
Fluorescent street lighting gives such excellent visibility that it should do much to reduce accidents after dark and may well revolutionize all accepted ideas and methods of street lighting.
The BTH Lighting Advisory Service is available to all concerned with street lighting projects.

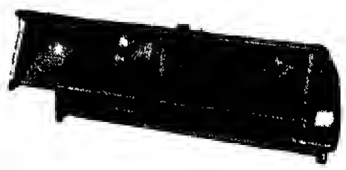
ENGINEERING & LIGHTING EQUIPMENT CO., LTD., ST. ALBANS, HERTS

THE "ORBITAL" is one of a complete range of fittings available for Mercury Discharge Lamps of 250/400 watt, the body is constructed of cast aluminium alloy, which has been proved in service for the past ten years. Each lantern is dispatched completely wired. Robust construction is an outstanding feature, and special attention has been paid to easy access to the interior. The distribution is by means of specially designed refractor prisms, which ensure the fullest possible utilization of light from the discharge lamp for road illumination.



"ORBITAL"

THE "GOLDEN-RAY" fitting incorporates specially designed refractor plates, combining horizontal and vertical prisms which ensure the fullest possible use of the light from the lamp for road illumination.
All component parts are of first-class material, and many thousands of these fittings were in service prior to the war. For use with 45, 60, 85 and 140-watt sodium lamps.



"GOLDEN-RAY"

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ENGINEERING & LIGHTING EQUIPMENT CO. LTD.—(*contd.*)

"ROYSTON"

THE "ROYSTON", with an hexagonal body is cast in one piece and focal positions for the two sizes of lamps are incorporated. The single piece dome refractor is available to give symmetric, axial or non-axial distribution, and is held by an ingenious quick release device based on the bayonet principle, which has the additional feature that it is impossible to replace the refractor incorrectly when removed for cleaning. For use with 300/500 watt Tungsten lamps or 80 and 125 watt mercury fluorescent lamps.

"STEVENAGE"

THE "STEVENAGE" is similar to the "Royston" but with the addition of a clear outer globe which is held in a cast globe ring, the fitting being completely dust-proof.

"WELWYN"

THE "WELWYN" fitting is an original design embodying a one-piece aluminium alloy casting with an entirely new design of single-piece refractor, giving 170° distribution in the horizontal plane. Pre-determined fixing stops are incorporated to ensure that each size of lamp is in correct focal position in relation to the refractor. 60/200 watt Tungsten lamps or 80 and 125-watt mercury lamps can be fitted.

"WARE"

THE "WARE" is similar in design and construction to the "Welwyn" but has an additional clear outer globe held in a cast hinged ring, a combination of felt gaskets ensures that the fitting is dust-proof. Provision is made for fixing a 16 in. diameter vitreous-enamelled reflector if required.

"BALDOCK"

THE "BALDOCK". In place of the dome refractor and clear outer globe of the "Ware", the optical system of this lantern consists of a bowl refractor which is available to give axial or non-axial distribution. A smooth exterior surface facilitates maintenance and the fitting is dust-proof.

ENGINEERING & LIGHTING EQUIPMENT CO., LTD.—(*contd.*)

THE "PINNACLE" for use with 80 and 125-watt mercury discharge lamps and gas-filled lamps up to 200-watts. Where economy has to be a deciding factor in side street lighting installations there is a very great demand for this fitting. Made in two designs, 2-way and 3-way Front extension and 3-way Back extension, many thousands of these fittings are in service in all parts of the country. The detachable top and body are cast-iron, the top being held by 3 substantial screws. The porcelain lampholder is adjustable for correct local position and has an anti-vibration device which greatly reduces lamp breakage. The mirrored reflecting surface is treated to withstand climatic conditions and the individual sections are easily replaceable with the fitting in position.

The surface of the mirrored reflectors is dimpled to minimize glare and great care has been taken in setting them to obtain the best possible road illumination. The fitting is supplied to give either 160° or 180° plan distribution.

"PINNACLE"

GENERAL ELECTRIC CO., LTD., LONDON, W.C.2

Features common to nearly all G.E.C. street lighting lanterns are: (*a*) the lantern bodies are die-cast, (*b*) all the castings are of a light alloy chosen for its rigidity and high resistance to weathering and corrosion, (*c*) prismatic lantern glasses for the most part are made from heat-resisting glass and have smooth exteriors so that maintenance is facilitated, (*d*) curved prisms used in the refractors are covered by G.E.C. patents.

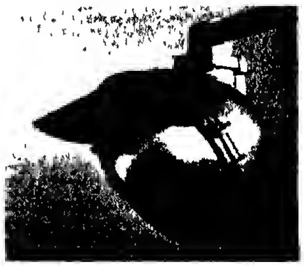
THE DIFRACTOR LANTERN is extensively used for nearly every kind of main road lighting, and will take either 250 or 400-watt Osira H.P.M.V. lamps. It employs a one-piece refractor bowl with internal curved prisms to provide the necessary redirection and diffusion of light. It has a spun top which is removable to give access to the focusing arrangements, and the bowl is hinged so that lamp replacement is easy. Side mounting suspension gives rigidity and provides easy fixing. This lantern can be converted for use with 300 or 500-watt Osram filament lamps by the simple addition of an inner symmetric dome refractor.

DIFRACTOR LANTERN

THE DIOPTRION LANTERN gives a controlled cut-off form of distribution and is for use on broad roads where wide distribution is necessary. It is designed for use with horizontally-burning 250 or 400-watt Osira H.P.M.V. lamps. The design of the optical system is such that a rapid reduction in candles above the peak reduces at high angles the amount of light which might otherwise produce glare. Arranged for side entry mounting, the body houses a series burning magnetic deflector for controlling the arc discharge and carries two large dish-shaped refractors with internal curved surface prisms.

DIOPTRION LANTERN

THE UNIWAY LANTERN gives uni-directional lighting and is designed for one-way streets or dual carriageways. Using either 80 or 125-watt Osira H.P.M.V. lamps it gives lighting results comparable with those obtained with 250 or 400-watt lamps in normal lanterns. The optical system is a one-piece silvered glass reflector of special design. A hinged door carries the front diffusing glass.

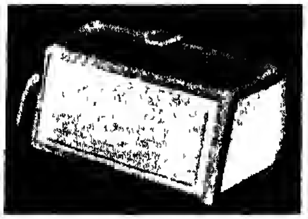


UNIWAY LANTERN

THE FACETED REFLECTOR LANTERN produces a directional type of lighting and is mainly for use on Class B roads. It will accommodate Osram filament lamps between 60 and 200 watts, or 80 and 125-watt Osira H.P.M.V. lamps. There are six mirror facets in each of the two wings. These facets are removable and are interchangeable, so that replacement can easily be effected. The lantern complies with the M.O.T. requirements relating to glare ratio. Side-entry suspension at 30° from the vertical ensures that no condensation can enter the lantern from the bracket.

THE SMALL OXFORD LANTERN is of the totally-enclosed type and can be used with either Osram filament, or Osira discharge lamps of small denomination. The body is of spun copper, with a reinforced top. Variable focusing is provided and the light distribution is controlled by a small bowl refractor in combination with an inner symmetric dome refractor.

GENERAL ELECTRIC CO. LTD.—(contd.)

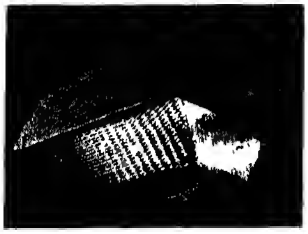


SIDE-STREET LANTERN FOR SODIUM LAMPS

THE SODIUM LANTERN FOR SIDE STREETS employs either 45 or 60-watt Osira sodium lamps. On each side, sealed prism refractor plates control the light distribution up and down the road and an opal panel, facing across the road, allows light to fall on the opposite pavement. The lampholder and lamp steady are carried on an over reflector which hinges downwards to facilitate wiring.

THE REFRACTOR PLATE LANTERN FOR SODIUM LAMPS is designed for main road lighting and can be used with 85 or 140-watt Osira sodium lamps. Prismatic plates of the sealed sandwich type control the distribution of light. Top entry suspension is provided.

HOLOPHANE LTD., LONDON, S.W.1



DILUX LANTERN

HOLOPHANE DILUX LANTERN

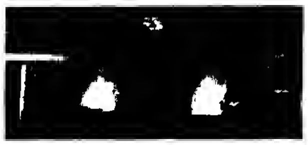
A new development in street lighting technique employing horizontal-burning Mercury Discharge Lamps, in conjunction with a highly efficient optical system providing semi-cut-off light distribution characteristics.

The high intrinsic brightness of the light source is shielded by the reflector assembly in the lantern hood, thus avoiding glare conditions, while the combined reflector refractor assembly affords a controlled two-way non-axial distribution, promoting adequate road surface and background brightness when installed in accordance with Group "A" Requirements.

DUO-DOME LANTERN

HOLOPHANE DUO-DOME LANTERN

These lanterns employ two-piece refractors so designed that the functional prismatic surfaces are internally sealed, presenting smooth exterior surfaces, thus facilitating cleaning and maintaining optimum efficiency over longer periods. Available in types suitable for Groups "A" and "B" roads, and all installation requirements.



LINEAL LANTERN

HOLOPHANE LINEAL LANTERN

Designed to provide suitable vertical and lateral light control in conjunction with Sodium Discharge Lamps. Two-piece refractor panels with internally sealed prisms and smooth exterior surfaces, re-direct the light flux into a well-controlled two-way non-axial distribution, while the low brightness of the refractor lantern ensures excellent visibility.

SINGLE-PIECE REFRACTOR

HOLOPHANE SINGLE-PIECE REFRACTOR LANTERNS

Simplicity and efficiency, together with low initial and operating costs, are the primary features underlying the design of this refractor lantern series. Available for lamp ranges suited to both Groups "A" and "B" installations, together with alternative refractor designs for symmetrical and two-way non-axial distributions.

HOLOPHANE LTD —(*contd*)

Holophane Bi-way Refractor Lantern

This lantern embodies one of the most advanced and efficient types of bowl refractors, designed for use with vertical-burning Mercury Discharge Lamps The light control is obtained by the use of patented reflector diffuser prisms carried on the inside of the glass, which are so designed as to give a wide spread of light at relatively low angles and a more restricted spread at high angles of emission, thus varying the width of the beams to match the angular width of the roadway at different angles of elevation

Two sizes are available, to suit Groups "A" and "B" installations, while the refractor bowl can be supplied in alternative types to provide symmetrical, two-way axial, or two-way non-axial distributions This lantern is also available for side entry mounting

Bi-way Lantern

W LUCY & CO, LTD, EAGLE IRONWORKS, OXFORD

These lanterns have a cast-iron watertight hood, with 12½ in diameter vitreous-enamelled reflector The centre of light is 8¾ in from the top fixing An adjustable spring-suspended B C lampholder enables lamps from 60 to 150 watts to be correctly positioned in the reflector The adjustment is simply made by means of the three nuts running on the studs which carry the suspension springs

Street Lighting Lantern

The overall height of pedestal and lantern illustrated is 15 in The opalescent globe is 12 in in diameter, but a 20 in globe can also be supplied The pedestal is of cast-iron A spring-suspended "Edison Screw" or B C lampholder is supplied suitable for lamps up to 200 watts

Directional Street Lighting Lantern and Pedestal Head

METROPOLITAN-VICKERS ELECTRICAL CO, LTD, LONDON, W C 2

Metropolitan-Vickers Electrical Co, Ltd, whose wide range of street-lighting lanterns was already well-known in the pre-war years, re-entered the market with a no-less attractive range of lanterns and lamps Small but valuable modifications have been incorporated in some of the lanterns, six of which are briefly described here It will be seen that in several instances the lantern can be used with alternative types of lamp, for example Mercury Discharge, Fluorescent Mercury Discharge, or Metal Filament

The Trafford Lantern for Group "A" Roadways

The Trafford Lantern is designed to utilize to the full the advantages of broad distribution in plan and fine control in the vertical plane inherent with an horizontal Mercury Vapour lamp, and incorporates a bowl refractor controlling a maximum proportion of the light emitted by the lamp

The mechanical construction of the Trafford lantern is exceedingly robust and consists in the main of a one-piece casting forming the canopy and bracket entry boss, and a detachable "hook-hinge" ring, which supports the bowl The bowl is made of special heat-resisting glass which remains unaffected even when chilled water is sprayed on the bowl after it has been heated to a higher temperature than could be obtained in actual service.

The "Trafford"

METROPOLITAN-VICKERS ELECTRICAL CO., LTD.—(contd.)

THE "GOWER"

THE GOWER LANTERN FOR GROUP "A" ROADWAYS

The body is of heavy gauge sheet copper riveted to a cast-iron canopy embodying a cool wiring chamber. The lantern has an inner reflector of vitreous-enamelled steel. Easily accessible porcelain-insulated terminals are connected to the lampholder by heat-resisting cable, and focusing is obtained by lamp carrier adjustment.

The standard pattern is "non-ventilated." When required for use with Fluorescent Discharge Lamps, a ventilated pattern is supplied.

The one-piece bowl refractor can be supplied in three forms, for two-way axial, two-way non-axial, or symmetrical distribution. This lantern offers an unusually wide range of light outputs because it can be used with any one of six lamps: (a) 250-watt or 400-watt Metrovick Mercury Discharge, or (b) 80-watt or 125-watt Metrovick Fluorescent Mercury Discharge or (c) 300-watt or 500-watt Cosmos Gasfilled Metal Filament. A dome refractor and clear outer well glass is supplied for use with Metal Filament Lamps.

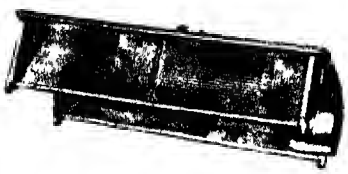
THE "URMSTON"

THE URMSTON LANTERN FOR GROUP "A" ROADWAYS

A notable feature of this lantern is its pleasing symmetry, which is not impaired by the neatly disposed bracket entry.

The Body is a weather-resisting aluminium alloy casting to which the bowl refractor is secured by means of a stout carrier ring fitted with a hook hinge and two wing-nuts. The one-piece canopy is a copper spinning, the inner reflector being of vitreous-enamelled sheet steel.

Like the "Gower" lantern it can be provided with alternative bowl refractors for two-way axial, two-way non-axial or symmetrical distribution, and it will accommodate any of the same range of lamps.



THE "POPLAR"

THE POPLAR LANTERN FOR GROUP "A" AND GROUP "B" ROADWAYS

This lantern is made in three different lengths to suit lamps of different outputs. It has a cast-iron top and cast aluminium endplates, the refractor plates being supported in stout copper channels. Each of the prismatic glass plates has both vertical and horizontal prisms to ensure maximum utilization of the light emitted by the lamp. The standard design embodies one-piece plates, but two-piece plates giving a smooth surface both outside and inside can be supplied. The standard distribution is at 160°, but a distribution at 180° can be supplied if required. The "Poplar" lantern is designed to accommodate a Metrovick Sodium Discharge lamp of 45, 60, 85 or 140 watts.

THE "EALING"

THE EALING LANTERN FOR GROUP "B" ROADWAYS

The body of this lantern is of stout sheet copper finished with heat-resisting aluminium paint, the cast-iron canopy is removable to facilitate wiring. It has an inner and an outer reflector of vitreous-enamelled steel. The standard pattern is that known as "non-ventilated dust-proof." Alternative lampholder positions are provided.

Supplied with bowl refractors giving either two-way non-axial distribution, or symmetrical distribution.

Any of the following lamps can be used: (a) 80-watt or 125-watt Metrovick Mercury Discharge, or (b) 100-watt or 200-watt Cosmos Metal-filament.

THE "ALDWYCH"

THE ALDWYCH LANTERN FOR GROUP "B" ROADWAYS

This top-entry lantern has a one-piece body of cast-iron with a hinged vitreous-enamelled pressed-steel reflector which supports a clear glass (weather-excluding) bowl.

An external adjuster head on the reflector canopy provides for lamp focusing.

The six-inch diameter one-piece refractor is secured to an internal reflector by means of three spring-loaded hooks. Three types of refractor are available giving respectively two-way axial, two-way non-axial, and symmetrical light distribution.

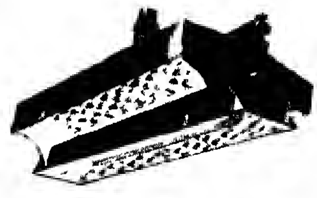
This lantern accommodates (a) a 100-watt or 200-watt Cosmos Metal-filament lamp, or (b) an 80-watt or 125-watt Metrovick Mercury Discharge lamp. Either a B.C. (2-pin or 3-pin) or an E.S. lampholder is supplied with the lantern.

REVO ELECTRIC CO., LTD., TIPTON, STAFFS

There are three distinct methods of light control which form the basis of the design of street lighting fittings in common use: the cut-off, the semi-cut-off and the non-cut-off. The accompanying illustrations show examples of each of these types for use with Sodium and Mercury vapour electric discharge lamps.

Cut-off Lantern

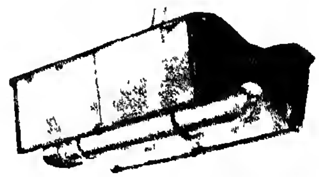
C 9777 illustrates a lantern suitable for 140-watt Sodium lamp in which the light source is completely screened at approximately 20° below the horizontal. It is specially designed, however, to allow a certain amount of reflected light to be emitted up to 10° below the horizontal so that the spacing-height ratio can be greater than that usually associated with cut-off fittings without causing alternate light and dark bands to appear across the width of the thoroughfare.



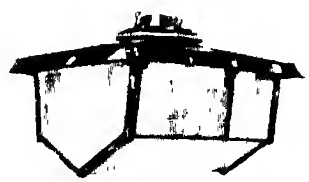
C 9777 Cut-off Lantern for 140-watt Sodium Lamps

Semi-cut-off Lantern

The special feature of the lanterns C 10735 and C 10766 is the independent control of the light by reflectors and refractors, thus directing the light emission with the minimum of loss. In this type the maximum candle-power is emitted at 15° below the horizontal and the intensity is progressively reduced above this angle.
It is recommended in the Final Report (August, 1937) of the Departmental Committee on Street Lighting set up by the Ministry of Transport that the distribution of light from lanterns "should be designed primarily to produce as uniform and high a background brightness as possible subject to the avoidance of undue glare. . . . The background includes not merely the carriageway and footway surfaces, but also other surfaces such as those of buildings or fences against which objects may be seen". It follows that to obtain uniformity of brightness across the whole width of the essential background it is necessary that sufficient light be emitted laterally from the lanterns to illuminate the sides of a thoroughfare and produce on those regions a brightness which may be comparable with the brightness of the carriageway. This has been taken into account in the design of the lanterns illustrated, the lateral spread of the light being sufficiently wide to ensure a high degree of brightness uniformity over the total useful background when the lanterns are correctly spaced and sited.
The normal spacing-to-height ratios on straight roads are 4 : 1 for the cut-off type and up to 6 : 1 for the semi-cut-off and non-cut-off types. Where a road bends, however, it is important that lanterns to the non-cut-off, or semi-cut-off type are correctly sited so that successive lanterns do not appear to be too widely separated from the motorist's viewpoint. This limitation of the desirable angular separation of successive lanterns may involve linear spacings of as little as 60 ft. where pronounced bends occur. In the case of the cut-off type, experience has shown that the angular separation is not so important, so that a fairly uniform linear spacing can be adopted regardless of bends.
The lanterns illustrated are suitable for the lighting of Class A roads to the requirements of the Ministry of Transport when mounted at a height of 25 ft.
This Company also manufactures a large range of lanterns suitable for Class B roads, for which the recommended mounting height is 15 ft. Among other products are ornamental lanterns to suit local architectural features, and also standards and brackets of pleasing design.
The Company has its own Technical Research Department which is constantly developing new principles of light control and applying them to various types of apparatus, as well as assisting responsible authorities with their own peculiar street lighting problems.



C 10735 Semi-cut-off Lantern for 140-watt Sodium Lamps



C 10766 Semi-cut-off Lantern for 250/400-watt Horizontal Mercury Lamp

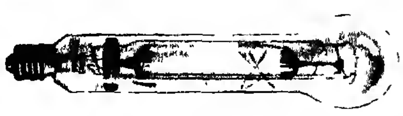
Non Cut-off Lantern

C 10392 shows an example of a lantern of the non-cut-off type for use with 250-watt or 400-watt vertically-burning mercury vapour lamps. In this type a high value of candle-power is emitted at angles near to the horizontal for the purpose of taking full advantage of the specular component of light reflected from the road surface at large angles of incidence.

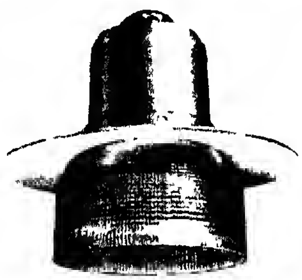
C 10392 Non-cut-off Lantern for 250/400-watt Vertical Mercury Lamp

SIEMENS ELECTRIC LAMPS & SUPPLIES LTD., LONDON, E.C.4

Years of research and practical experience prior to 1939 resulted in lamps and equipment being designed and a technique of application being evolved which, when properly combined, produce excellent electric street lighting at a reasonable cost. To-day this well-established technique is still up-to-date and consequently radical changes in street lighting equipment have not, in recent years, been necessary. It follows that the equipment available for street lighting to-day is substantially the same as that produced in the immediate pre-war years.



THE SIERAY-DUAL LAMP



THE NEWTON-SIERAY LANTERN

SIERAY Mercury and Sodium Vapour Electric Discharge and SIEMENS tungsten filament gas-filled lamps are available in suitable wattage ratings, whilst SIERAY-DUAL lamps meet the requirements of those Authorities who wish to install electric discharge lamps on direct current supplies, those who favour the improved quality of the light emitted by these lamps, or where capital cost is important.
The application of SIERAY Fluorescent tubular lamps to street lighting is under consideration and it is felt that these lamps have a considerable potential value in important centres of large towns, where the colour of their light and low brightness are likely to be attractive.

With regard to lanterns, a new single-piece prismatic dome refractor has been designed and is used in a range of lanterns known as the NEWTON-SIERAY type, features in the design of which make a ready appeal.

Whilst every care has been taken in compiling this information, the omission of any name must not be held as implying any deficiencies in the products of any company concerned.

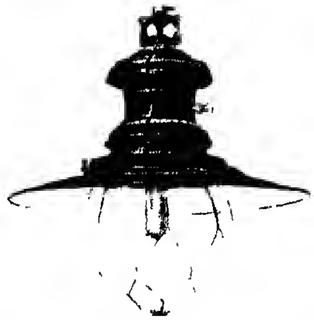
GAS LIGHTING

KEITH BLACKMAN, LTD., LONDON, N 17

The KEITH system of high-pressure gas lighting consists of boosting the towns' gas supply from the normal 3 ins water column pressure to a pressure of 81 in to 90 in water column (3 to 3½ lb pressure), imparting to the gas the energy to entrain the requisite amount of air at the injector of each lamp and so form a self-burning mixture.
The KEITH Lamps have been designed specially for the KEITH System, and are made in sizes of 500 c p, 1,000 c p, 1,500 c p with one mantle, also two-light and three-light column and suspension lamps with a candle-power up to 4,500

"KEITH" SUSPENSION LAMPS SQUAT TYPE

A single-light lamp of "Squat" type generally supplied, usually in 1,000 candle-power size. The lamps can be arranged with automatic lighters or governed flashing by-pass cocks. The former, where lamps are controlled from a central compressing station, automatically light up and extinguish.



"KEITH" SQUAT TYPE SUSPENSION LAMP

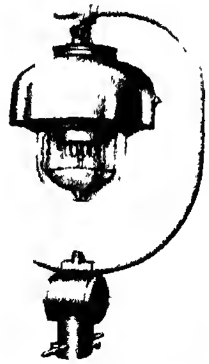
"SUPERVIA" LAMPS

Specially designed for street lighting, suspended either from bracket arms on columns or walls or centrally suspended from span wires across the street. This lamp was designed in conjunction with the South Metropolitan Gas Co. For illustration see p 142

WILLIAM EDGAR & SON, LTD., LONDON, W 6

THE "RIVERCOURT" LAMP

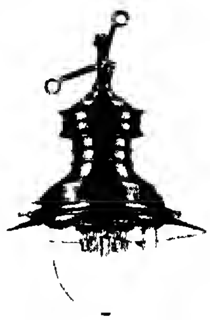
A modern type of lamp, specially designed for present-day requirements of street lighting. A very high standard has been attained, and the general appearance of the lamp with its unbroken contour is exceptionally attractive. Fine gas and air regulators are provided, which when correctly adjusted, can be securely locked, obviating any displacement by vibration. The lamp is fitted with a Distant Control apparatus. The superheater box of the burner carries five or six "Long Bijou" mantles, having a gas consumption of 2 cubic feet per hour each.



THE "RIVERCOURT" LAMP

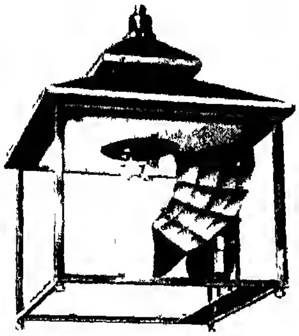
THE "ECLIPSE" LANTERN

A modern suspension-type lantern of pleasing appearance, which owing to its wind-proof qualities, can be fixed in extremely exposed positions. Fine gas and air regulators are provided, which, when correctly adjusted, can be securely locked, obviating any displacement by vibration. The lamp can be arranged for upright fixing if required, and can be manufactured in any size up to ten light.



THE "ECLIPSE" LANTERN

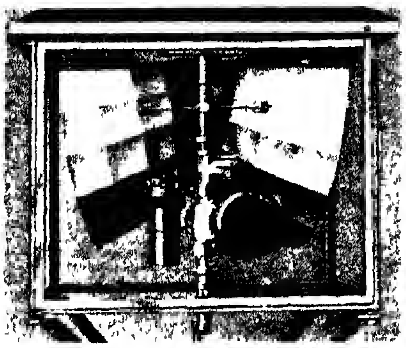
W PARKINSON & CO, BIRMINGHAM, 9



COMPLETE MAXILLA SUSPENSION LANTERN

The Post-war MAXILLA range of upright and suspension Lanterns has been designed especially for residential areas and roads for Group "B" Lighting to Ministry of Transport requirements, and embraces a vast improvement on the pre-war Maxilla Lanterns.

The astragals are made as narrow as possible, so that, with the frog sprays twisted to present the smallest surface to the path of light, shadows have been reduced to a minimum. The street lighting effectiveness has also been enhanced by the adjustability of the facected reflectors which are constructed of aluminium anodized by an improved process.



REAR VIEW OF MAXILLA LANTERN

Rectangular sides replace the tapered in order to facilitate easy replacement of five glass panes (sides and base), each being of identical size. Heat resisting glass panes are introduced into the lantern with the larger size burner assembly and are placed opposite the forty-faceted Reflector.
Standard interchangeable parts have been adopted where possible which has reduced the cost of manufacture and the number of components required as spares. The hoods are stamped in one piece throughout ensuring resistance to weather and are constructed of copper.

The whole of the burner assembly, from nipple to pre-heater is the same for all lanterns and for all sizes of pre-heaters from 2 to 6 light. The standard venturi tubes and fixed nipple are controlled to the size required for the particular size of pre-heater. Fixed nipples and constant-pressure governors are introduced as standard components of these Lanterns. The venturi maintains the 1 7 taper whatever quantity of gas is passed. A strong centre feed casting with provision for inset safety chain is fitted to the suspension lantern.

REMOVAL OF REFLECTOR ASSEMBLY

The back view of the MAXILLA Upright Lantern, as illustrated, shows ignition device, clock controller and constant-pressure governor, neatly housed and concealed behind the faceted reflectors. The latter are supported by a tripod fitted to the venturi and permitting vertical adjustment. The control assembly can be easily removed with "Comet" Igniter, as illustrated. The fly-cap tightened union at the base of the nipple holder permits this easy removal of the controls, faceted reflector and venturi tube, the latter being "olived" at the top to make a gas-tight push-fit connection with the burner supply tube.

WILLIAM SUGG & CO, LTD., LONDON, S W 1

THIS company is chiefly concerned with providing low-pressure gas-lighting equipment, able to give results fully in accordance with modern practice, as outlined in Ministry of Transport Final Report on street lighting and B S Specification, now in the course of revision.

All standards of street lighting have been most satisfactorily developed by the employment of the well-known ROCHESTER Lamp, in suspension or upright form, and the Square WINDSOR Lantern.

For cut-off installations, the FOLKESTONE Lamp was introduced shortly before the war (see p. 140).

WILLIAM SUGG & CO, LTD—(*contd*)

The more recently introduced LONDON lamp has been popularly adopted for the high brightness type of street lighting. This unit has a wide lateral light distribution which is adjustable vertically and has been extensively used for Group "A" Lighting schemes (see also p. 138).

The "8000" Lamp is primarily designed to replace existing square lamps. Its controlled light distribution greatly improves the visibility without increasing the gas consumption. This Unit constitutes the ideal conversion for bringing old gas installations up-to-date, at the lowest possible cost (see also p. 143).

For new installations, such as new Housing Estates, the Type "G" "8000" Lamp is the ideal lighting unit. This model is mounted on a concrete bracket arm and column, the bracket arm embodies the control equipment, enclosed in a steel housing, and concealed from view.

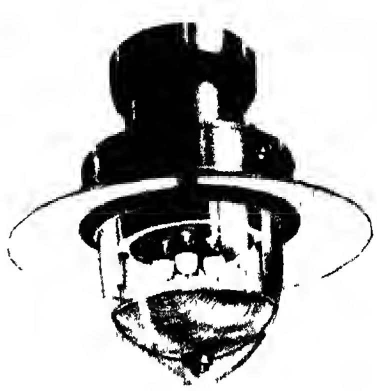
All lighting units are available equipped with fully automatic clock control, using by-pass or Horstmann COMET ignition, the latter system eliminates by-pass consumption and embodies a gas pressure-operated diaphragm valve, small battery and filament. The gas passing through the igniter is led through a tube to the igniter head, which contains a platinum alloy filament. The filament is heated by an electric current and causes instantaneous ignition of the gas, resulting in a flame being projected from the igniter head.

Master control for any number of lighting units can be arranged by the employment of The SUGG'S CENTRAL CONTROL SYSTEM. Simplicity is the keynote of this system, a small relay pipe is provided to operate the relay valves on lamps which are equipped with by-pass or "Comet" ignition.

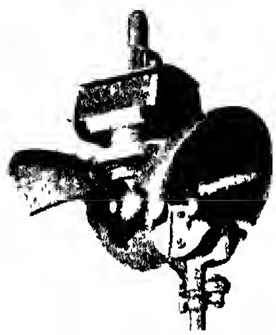
This method of control offers many advantages and is especially suitable for the numerous illuminated signs on traffic roundabouts, and new lighting installations, where its use can effect considerable economy. Disturbance of the existing supply pipes is unnecessary.

A feature of modern gas-lighting units which should not be overlooked, is that the greater part of their light is naturally directed in the lower hemisphere, and usually only 5 to 15% of the light from the lantern is lost upwards, the proportion of light thus radiated usefully under service conditions is usually much higher than with competing illuminants of equal rating.

Recent advances in design and construction have resulted in units being available which will give a very constant performance over many years. Another important factor is that the gas source produces a light which is akin to sunlight, and gives reasonably normal colour discrimination. The low-pressure gas lamp also possesses advantages in respect of avoidance of glare.



THE "ROCHESTER" WITH HOLOPHANE REFRACTOR

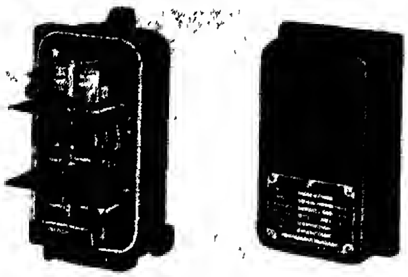


THE "8000"

Whilst every care has been taken in compiling this information, the omission of any name must not be held as implying any deficiencies in the products of any company concerned.

ACCESSORIES

AUTOMATIC TELEPHONE & ELECTRIC CO., LTD., LONDON, W.C.2



RYTHMATIC CONTROL SWITCH

RYTHMATIC CONTROL

This system enables twenty-four different selective switching operations to be effected, without mutual interference, over a power network from a central station It is equally effective on direct or alternating current networks The illustration shows the control switch with and without cover

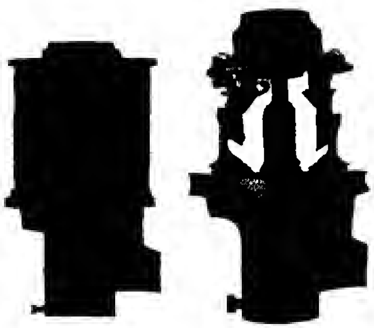
BRITISH INSULATED CALLENDER'S CABLES, LTD., LONDON, W.C.2

Electric cables for street lighting installations and ancillary equipment are among the products of the B I Callender Company Part of the organization concentrates on the development and manufacture of overhead lines and equipment for tramways and trolleybus services

CABLES & PLASTICS, LTD., LEEDS, 7

Plastic covered cables for all types of electric cable work and insulation

ENGINEERING & LIGHTING EQUIPMENT CO., LTD., ST ALBANS, HERTS

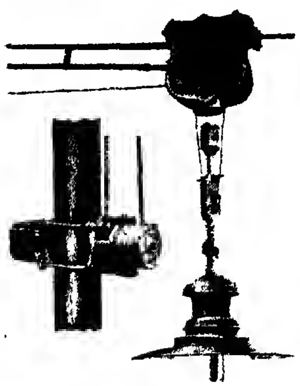


ELECO RAISING AND LOWERING GEAR

Steel and concrete poles and columns of all heights and sizes to meet requirements All types of fuse boxes, switch gear, raising and lowering gear and control boxes, etc

The raising and lowering gear illustrated enables lantern cleaning and lamp replacement to be effected with a minimum of trouble and traffic congestion Safety is assured as the weight of the fitting is completely independent of the wire rope when the fitting has been wound into position

KEITH BLACKMAN, LTD., LONDON, N.17



"KEITH" PATENT RAISING & LOWERING GEAR

"KEITH" PATENT RAISING AND LOWERING, AND RAISING, LOWERING AND TRAVERSING GEARS FOR GAS LANTERNS

The gears are made in two forms—type R L, for raising and lowering lamps attached to ceilings, brackets or arms on columns, etc , and type R L T, for raising, lowering and traversing lamps suspended from cables attached to buildings, or to columns on opposite sides of the street, etc. In both types means are provided for making sound gas connection, and for taking the weight independently of the wire hoisting rope when the lamp is in its working position

The R L T Gear shown is for central suspension R L T and R.L. Gears are equally suitable for high-pressure or low-pressure gas lamps

GENERAL ELECTRIC CO., LTD., LONDON, W.C.1

THE STREET LIGHTING ACCESSORIES chokes, capacitors, switches and the containers for housing them are robust and are designed to withstand the rigours of inclement weather conditions with a minimum of maintenance. G.E.C. chokes and leak transformers are solid-filled and are totally enclosed. The filling ensures complete protection from dampness and that the choke settings remain constant under all conditions.

RIPPLE CONTROL is an electronic system of remote switching control without switch wires. In this system, the general principles of which are well-known, alternating currents of musical frequencies between 300 and 800 C.P.S. are injected into the supply mains and operate tuned relays at the points to be controlled, e.g. street lanterns.

Briefly the advantages of this G.E.C. system are: it is suitable for both A.C. and D.C. networks, the signals can be injected into either high tension or the low tension side of an A.C. network, the same type of signal is used throughout, new frequencies can be added without any alteration or addition to relays already installed, the receiving relays cannot get out of step, the system is independent of the strength and duration of the signalling current between very wide limits, it is independent of the state of the neutral conductor insulation.

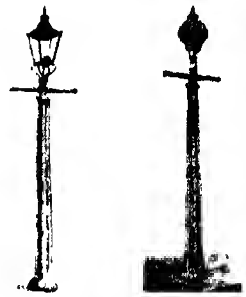
These features and all other relevant information are explained in detail in a brochure entitled "G.E.C. System of Centralized Control for Street Lighting" which is obtainable from The General Electric Co., Ltd., Magnet House, Kingsway, W.C.2.

HARDY & PADMORE, LTD., WORCESTER

Ornamental street lighting columns, switch pillar casings, and kiosks.

JOHNSTON BROS. (CONTRACTORS), LTD., DAWLEY, SALOP

Cornolith or plain lamp-posts, from 9 ft. 6 in. to 20 ft. high, for gas or electric supply. The Cornolith finish will successfully withstand the weather and gain in beauty as time passes. All necessity for painting is obviated. Arms are screwed into a metal frog connecting to centre reinforcing pipe through post.

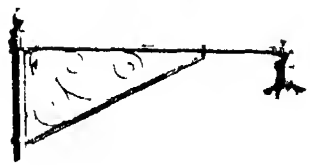


CORNOLITH LAMP POSTS

W. LUCY & CO., LTD., OXFORD

POLE BRACKET

Single-arm type pole bracket for main thoroughfare lighting. Projection from pole to centre of light is 8 ft. but can be made with any projection to suit engineers' requirements.

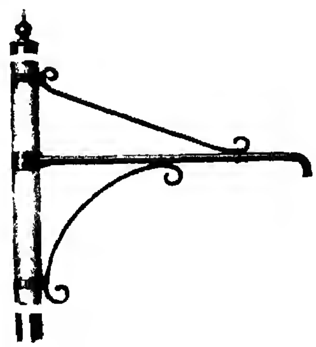


POLE BRACKET

REVO ELECTRIC CO., LTD., TIPTON, STAFFS

POLE MOUNTED BRACKET

Pole mounted lighting bracket, made of wrought iron, enamelled in green. Strength in construction is a prominent feature in every design, each bracket is manufactured from steam barrel tubing ensuring greater durability.

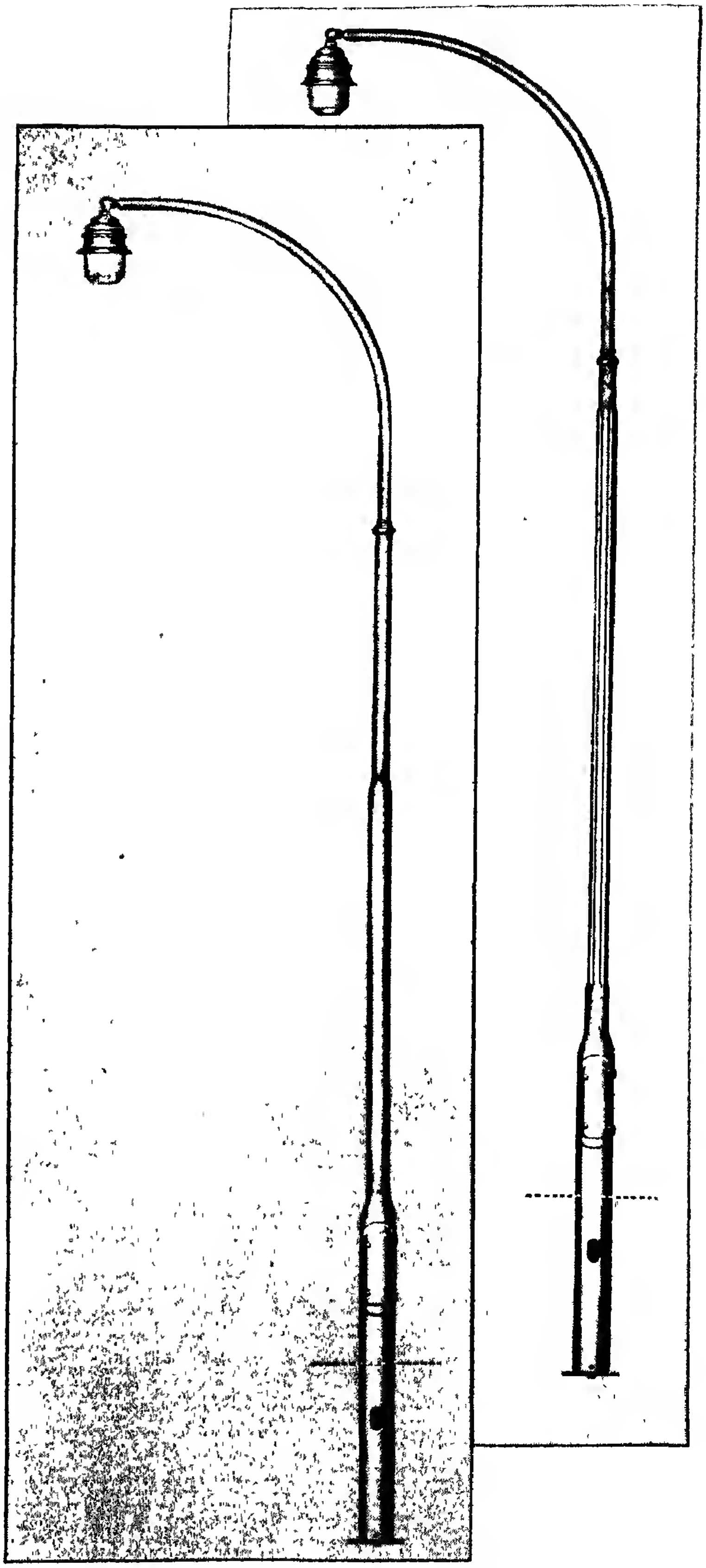


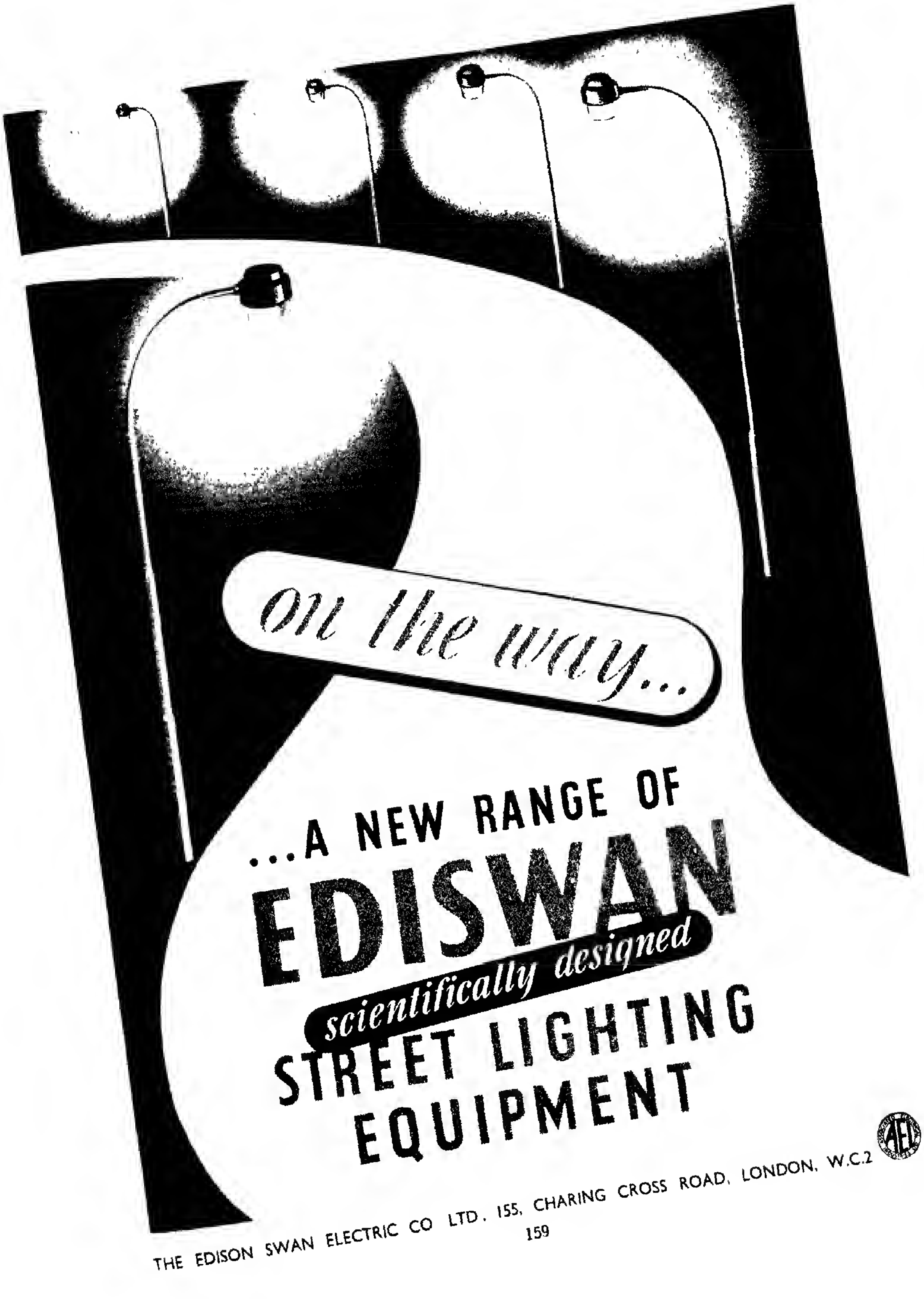
POLE MOUNTED BRACKET

STANTON IRONWORKS CO., LTD., NR. NOTTINGHAM

Lighting columns from 9 ft. to 26 ft. 6 in. high, manufactured by spun process granite aggregate to B.S. 1308: 1946.

Whilst every care has been taken in compiling this information, the omission of any name must not be held as implying any deficiencies in the products of any company concerned.




on the way...
...A NEW RANGE OF
EDISWAN
scientifically designed
STREET LIGHTING
EQUIPMENT
THE EDISON SWAN ELECTRIC CO LTD, 155, CHARING CROSS ROAD, LONDON, W.C.2

Engineering & Lighting Equipment Co Ltd, "Golden Ray" Lanterns at 120' x 25' with Philips SO H 140W Sodium Lamps

PUBLIC lighting installations using Philips mercury or sodium lamps are ensuring road safety all over the country and in many parts of the Empire. The use of these efficient light sources, in suitable lanterns at recommended spacings and heights, provides high visibility for low lighting costs and energy consumption. Philips Illuminating Engineers are at your disposal in all parts of the United Kingdom to give lighting advice without obligation.

PHILIPS DISCHARGE LIGHTING

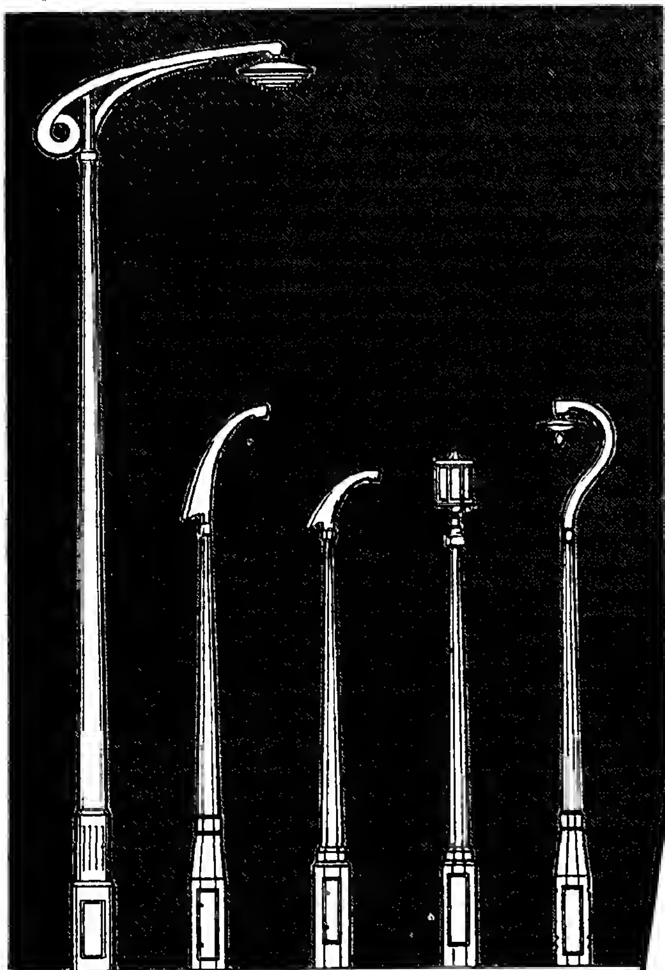
FLUORESCENT
MERCURY
SODIUM

PHILIPS LAMPS LIMITED, (LIGHTING DEPARTMENT)
CENTURY HOUSE, SHAFTESBURY AVENUE, LONDON, W.C.2

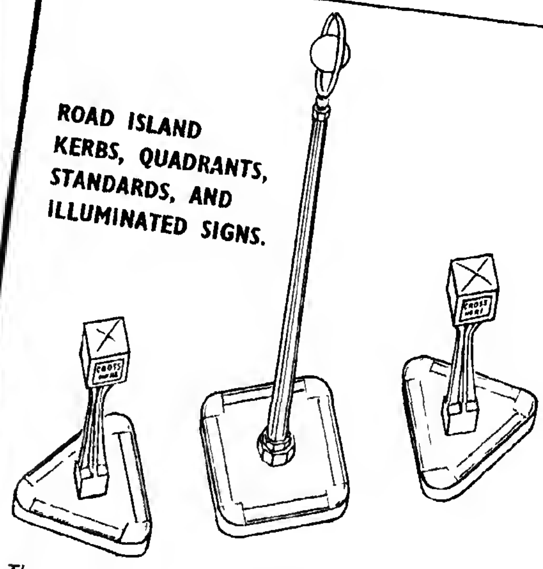
Branches & Sales Depots at:
Birmingham, Bristol, Blackburn, Cardiff, Edinburgh, Glasgow, Leeds, Liverpool, Manchester, Newcastle-on-Tyne, Nottingham, Sheffield
(215P)

GIRLING *Reinforced Concrete*

LAMP STANDARDS AND ROAD ISLAND SITES



- WELDED STEEL REINFORCEMENT ENSURES MAXIMUM STRENGTH
- CAST BY ELECTRO-MAGNETIC VIBRATION FROM SPECIALLY SELECTED AGGREGATES
- LIGHT IN COLOUR WITH SMOOTH OR POLISHED FINISH
- NO PAINTING OR MAINTENANCE COSTS



ROAD ISLAND KERBS, QUADRANTS, STANDARDS, AND ILLUMINATED SIGNS.

The complete Island site with kerbs, "Keep Left" signs and Lamp Columns, can be supplied in high-grade vibrated concrete. Pleasing textures can be given to surfaces if required. The Lamp Columns used are from our standard range.

Surveyors, Highway Engineers, and all concerned with immediate or future plans for street lighting and road safety installations, are requested to apply for full particulars of the latest designs of concrete lamp standards and island sites fabricated by GIRLINGS The services of our Drawing Office and Advisory Technical Department are available for advice and assistance on all matters involving the use of pre-cast concrete products Enquiries are invited.

BY APPOINTMENT Suppliers of Ferro-Concrete Work

GIRLINGS' FERRO-CONCRETE CO. LTD.

SOUTH: Great West Road, Feltham, Middlesex. Telephone: HOUnslow 1158-1159
MIDLANDS: Rothwell, near Leeds. Telephone: Rothwell 3174 (Leeds Extension)
SCOTLAND: Southbank Road, Kirkintilloch, Glasgow. Telephone: Kirkintilloch 2244-5

Section Five

ROADMAKING MATERIALS

GENERAL SURVEY OF MATERIALS

By W. P. ROBINSON, C.B.E., B.Sc., M.Inst.C.E.

NATURAL stone may be classified into groups for geological purposes under about sixty different names but the quarrying industry uses eleven principal groups, i.e. Artificial, Basalt, Flint, Gabbro, Granite, Gritstone, Hornfels, Limestone, Porphyry, Quartzite and Schist.

GRAVEL

Gravel is not included in any group, since it is not a kind of stone but a word used to signify "rounded or water-worn stones of irregular shape and size occurring in natural deposits, with or without some finer material." The stones in gravel may fall within one or more of the group names mentioned above. Screened gravel may be regarded as all material retained on a $\frac{3}{16}$ in. sieve. Gravel is used for surfacing roads and footways, for blinding tar or bitumen when used as a surface dressing, for foundations and sub-bases for surfacings and as aggregate for concrete. When used for surfacing with only water as a binder the screened gravel should contain a proportion of sand and clay to fill the voids, the proportion depending on the size and grading of the material rejected by a $\frac{3}{16}$ in. sieve. When used for blinding surface dressings of tar and bitumen, the gravel should be screened all to pass a $\frac{3}{4}$ in. screen and should contain a proportion of sizes from $\frac{3}{4}$ to $\frac{3}{16}$ in. in order to give a covering as free of voids as practicable.

For foundations the larger stones may be used as bottoming or hardcore, provided the interstices are filled with finer material containing a sufficient portion of binding material. By suitable control of grading and water content and by adequate compaction, the use of gravel for foundations and sub-bases is likely to be extended as knowledge of soil mechanics increases. The sub-base to the concrete runway at Heath Row Airport largely consists of gravel found on the site spread and compacted by machinery (see article on Soil Stabilization, page 58). Gravel is extensively used for making concrete. River and pit gravels, when properly screened so that the grading may be controlled, form excellent aggregates, both coarse and fine. Care should be exercised in the use of beach gravel and tests should be made prior to use to determine the presence of salts injurious to the cement.

Provided adequate attention and control are exercised in the grading of gravel and a suitable binder, such as cement, bitumen or tar, is used in suitable proportions, the use of gravel as a road surfacing may increase. The sizes to which the gravel may be screened and certain gradings have been standardized by the British Standards Institution (see B.S. Specification No. 882 · 1940). Gravel dredged from river beds and valleys, e.g. the Thames, locally known as "all-in ballast", is frequently used, unscreened, as an aggregate for concrete. It often contains an excess of sand necessitating the use of more water to provide easy workability. All-in ballast has been successfully used for concrete for sub-bases and as a backing to kerbs, using 14 parts by weight of aggregate to 1 part of cement and a water/cement ratio of 0.50, compaction being obtained by the use of a pneumatic vibrator, but the lack of uniformity in the grading of the aggregate as dredged is likely to cause trouble unless the grading is carefully controlled.

MACADAM

In the B.S.I. Glossary No. 892 · 1940, macadam is defined as "crushed or broken stone of regular sizes below 3 in. for carriageway construction. The smaller sizes below 1 in. are more specifically defined as chippings." The harder and tougher the stone the more durable it will prove for road surfacings generally but softer stones may be used if protected by suitable binders.

Macadam is usually produced by machine crushers to sizes standardized by the B.S.I. Stones rejected by a 3 in. square sieve are usually used as pitching, soling, penning or hardcore. Stones passing a 1 in. sieve are generally defined as "chippings". The following sizes of broken stone have been standardized by the B.S.I.: $2\frac{1}{2}$, 2, $1\frac{1}{2}$, 1, $\frac{3}{4}$, $\frac{1}{2}$, $\frac{3}{8}$, $\frac{1}{4}$, and $\frac{1}{8}$ in. These dimensions are normal sizes but each piece may vary in size, e.g. a 2 in. nominal size stone may be $3\frac{1}{2} \times 2\frac{1}{2}$ in. and yet pass a $2\frac{1}{2}$ in. square opening. The B.S.I. Standard for 2 in. stone specifies that not more than 15 per cent shall be retained on a 2 in. square opening, all shall pass a $2\frac{1}{2}$ in. opening, 70 per cent shall be retained on a

$1\frac{1}{2}$ in opening and not more than 5 per cent shall pass a 1 in opening For other normal sizes see B.S. 63 : 1913. The shape of the pieces is important and should be as cubical as possible, avoiding flakiness Frequently the harder rocks break into flaky shapes Difference of opinion prevails as to the merits of using one size of stone or mixing for use in one course, and B S. 63 permits wide tolerance in any one size Essentially the voids in any macadam surfacing should be filled either with stone or a mixture of stone, sand, cement or bituminous binder if the surfacing is to resist the action of weather and traffic The smaller the voids in macadam road crusts, the less binder will be required and greater density, strength and resistance to weather and wear will result

Macadam may be laid and rolled dry, the binder afterwards added, the whole then being compacted; this process is known as grouting, alternatively the macadam and binder may be previously mixed before spreading and compacting

When macadam is laid and rolled dry and the binder is added after rolling, it is impracticable to ensure that the rate of adding binder exactly to fill the voids is correct Owing to the varying sizes of the stones, the crushing under the roller, segregation whilst transporting, unloading and spreading, there must be lack of uniformity in the volume density of the macadam after rolling Experience has shown that, if insufficient binder is used, attrition and wear soon occur, while excess of binder leads to slipperiness, corrugation and deformation of the surface Nevertheless, carefully made grouted surfacings are practicable on roads not carrying a very large volume of traffic as well as on minor roads of a rural character Stricter control of the grading of the stones and the quantity of binder required is possible when the stones and binder are mixed in a suitable mixer before being spread on the road or formation

Most natural rocks provide satisfactory aggregates for macadam when coated with a suitable binder, the grading and proportioning of the aggregate and binder being more important than the nature of the aggregate Granite, basalt, limestone, gravel and slag are extensively used but soft limestones should be avoided Gravel is more difficult to bind on account of its round shape and smooth surfaces, while slag, often honeycombed, requires more binder than crushed hard rock Whatever the nature of the rock and binder, uniformity in the grading and proportion of binder and maximum density after compaction should be aimed at to ensure maximum efficiency under traffic.

BITUMINOUS MACADAM*

As distinct from asphalt made hot, bituminous macadam comprises all mixtures of stone, gravel, slag or clinker aggregate with a binder of tar, soft or cutback bitumen or emulsions of tar or bitumen. (See Appendix No 1, page 184, for appropriate British Standard Specification)

BITUMEN

The definition of bitumen given in the Standard Glossary is, "a mixture of hydrocarbons of natural or pyrogenous origin or combinations of both (frequently accompanied by their non-metallic derivatives), which can be gaseous, liquid, semi-solid or solid and which are completely soluble in carbon-disulphide"

Natural bitumen is found in nature in combination with mineral matter, such as Trinidad Lake, and other deposits, and *residual* bitumen is obtained by the distillation of petroleum oil (see B S 511 1933 for definitions) The natural bitumens as found in nature are too hard and brittle for use and have to be softened by the addition of a flux of either residual bitumen or oil, the degree of hardness being tested by a penetrometer The depth of the penetration of a standard needle in millimetres in five seconds at 25 C under a load of 100 grammes is an indication of the hardness, the harder the bitumen the less being the penetration Bitumen can be emulsified by the addition of soap or other agent Bitumen emulsions containing 40 to 50 per cent water are useful for grouting macadam, for surface dressing and for mixing with aggregates where heat or plant is not available for hot mixes and processes, but all these processes are more sensitive to adverse weather conditions than when using cutback bitumen † Both natural and residual bitumens are extensively used as binders with stone for coated macadam and asphalt surfacings and base coats, for surface dressing, and in damp courses in bridgework The fluidity of bitumens is measured by a viscometer The viscosity is expressed as the time taken by a stated volume of bitumen to flow through a standard orifice under controlled conditions

ASPHALT ‡

The Standard Glossary of Highway Terms defines asphalt as "a natural or mechanical mixture in which asphaltic bitumen is associated with inert mineral matter"

* See also article on Coated Macadam, page 193
† See also article on Road Emulsions, page 198.
‡ See also article on Asphalt Roads, page 189.

For road surfacings there are three types rock, mastic and rolled asphalt

All asphalt surfacings should be mixed, laid and compacted whilst hot, at a carefully controlled temperature. Their strength and resistance to wear largely depend on the correct proportioning of the fine material and filler with the stone, the quantity and properties of the bitumen and the degree of compaction of the mixture

For rolled asphalt there is a large variety of mixtures in use, variations being necessary to suit climate, thickness of wearing crust, nature of stone and binder available and density of traffic Mixtures of sand and bitumen (sand carpets) have been used but the addition of stone tends to improve stability and non-skid properties and to reduce the quantity of bitumen required as a binder The largest size of stone should not exceed 50 per cent of the compacted thickness of the surfacing

TAR*

Definition "a bituminous product, viscous or liquid, resulting from the destructive distillation of organic materials" The word "tar" should be preceded by the name of the matter from which it is produced, i e, coal, shale, peat, vegetable matter, etc Its mode of production should also be indicated Refined tar is defined as "high temperature coal tar from which the water and more volatile oils have been removed by distillation"

B S 76 . 1943 refers to tars used for making tarmacadam, tar carpets or surface dressing and provides for three types, A B. and C. Type A is used in the manufacture of tarmacadam for base course work, for close textured dense carpets and for surface dressing, type B for tarmacadam and medium textured carpets and type C for open textured carpets Type A has the most rapid setting properties, type B is medium and type C slow setting The consistency of tars is measured by their viscosity, the time in seconds taken for 50 ccs of tar to flow through an orifice 1 cm. in diameter at a defined temperature The standard temperatures are 30, 35, 45 and 50°C These temperatures vary to suit different viscosities

In order to make comparison easier, a new method of expressing viscosity has been introduced known as the *equi-viscous temperature*, which is the temperature in degrees Centigrade at which the tar has a standard viscosity of 50 seconds Tar is more susceptible to temperature changes than bitumen, in other words it is harder at low temperatures and softer at high temperatures Tar can be emulsified with water and emulsions containing 40 to 50 per cent of water may be used for making tarmacadam and for surface dressings. The emulsions, being in a liquid state, may be used at a normal or low temperature, the binding property resulting from the evaporation of the water Consequently, the use of emulsions is largely dependent upon atmospheric conditions Emulsions cannot be used at temperatures below freezing point

* See also article on Maintenance of Highways, p. 404.

CEMENT

Cement is defined as "a medium employed in a liquid or powdery condition which, upon hardening by cooling or hydration, will unite adjacent solid substances of a suitable nature" Cements used for highway purposes comprise bituminous, asphaltic, hydraulic and chemical cements Bituminous cements include tar, residual bitumen, pitch, tar and bitumen oils Asphaltic cements include natural bitumen alone or in combination with residual bitumen, tar or fluxing oils. Hydraulic cements include Portland (normal setting and rapid hardening), aluminous, e g Ciment Fondu, lime Chemical cements include magnesium chlorides, resins, waxes and sulphite liquors

CONCRETE

Concrete is defined as "a mixture of mineral aggregate with a binding or cementing agent which, on chemical action or temperature change, forms a solid mass" Bituminous concrete is a mixture of mineral aggregate with a mortar in which asphalt, bitumen or tar is the binding agent Cement concrete is a mixture of mineral aggregate with a mortar in which hydraulic cement is the binding agent. Bituminous and asphaltic cements are used in the manufacture of bituminous and asphalt surfacings, hydraulic cements are used in the manufacture of cement concrete for foundations, sub-bases, surfacings, bridges, walls and other structures Chemical cements are used for binding foundations for roads and bridges, for accelerating the setting of Portland cements, and for binding soil particles together.

The principal properties of Portland cement are: (*a*) rate of setting, (*b*) rate of hardening, (*c*) rate of heat emission during setting and (*d*) resistance to chemical action The rate of setting for normal Portland cement (B S 12 : 1940) and for rapid hardening cement is between 30 minutes and 10 hours, but the rate of hardening of the latter is much higher than the former. The rate of

hardening may be expressed as the rate of strength development. The rate of heat emission depends upon the rate of hardening, i.e. the more rapidly a cement hardens, the higher will be the temperature rise. Resistance to chemical action is important because certain chemicals in soil and water have an injurious effect on Portland cement but not on aluminous cement. Hydraulic cements in common use in Great Britain are known as normal Portland, rapid-hardening Portland, blast furnace, high alumina and quick-setting Portland.

AGGREGATES

Aggregates for cement concrete should be of clean, hard mineral free from particles that will collapse on exposure to the weather. The particles which pass a $\frac{3}{16}$ in sieve are known as "fine aggregates" and those retained as "coarse aggregates". It has hitherto been specified that aggregates should be clean, i.e. free from clay, loam and organic matter. While the presence of organic matter which would have a deleterious effect on the cement is injurious, the presence of clay or loam in suitable quantity might not have an injurious effect, provided that the quantity of water used in mixing is adjusted, and that the mixed materials are compacted to maximum density. Clay or loam should, however, be excluded as far as possible.

The grading of the sizes of particles used has an important influence on the workability of the concrete, the amount of water required to obtain workability and consequently upon the strength of the concrete. B.S. 882: 1940 deals with "Natural Aggregates up to $1\frac{1}{2}$ in. nominal size for Concrete for Structural Purposes". It has been estimated that the strength of concrete may vary as much as 20 per cent owing to the sole effect of the grading on the quantity of water required to produce concrete of uniform workability.* The limits of grading in B.S. 882 are necessarily wide in order to meet varying requirements, and it is consequently important to specify the grading required for each particular concrete. Such grading would naturally be determined by available sizes and the class of work on which the concrete would be used. For example, large quantities of all-in ballast, of which the grading varies extensively, have been used for lean mixes of less than 10 to 1 employed in sub-bases, haunching of macadam, foundations, etc. but for surfacing work where high strengths are necessary, the stone should be purchased in at least three nominal sizes and mixed by weight to obtain the required grading. The importance of a well designed mix cannot be over emphasized.

PROPERTIES OF GOOD CONCRETE

The essential properties of good concrete are maximum density, resistance to the absorption of water, high crushing strength, resistance to damage by fire, durability and resistance to wear by traffic and weather.

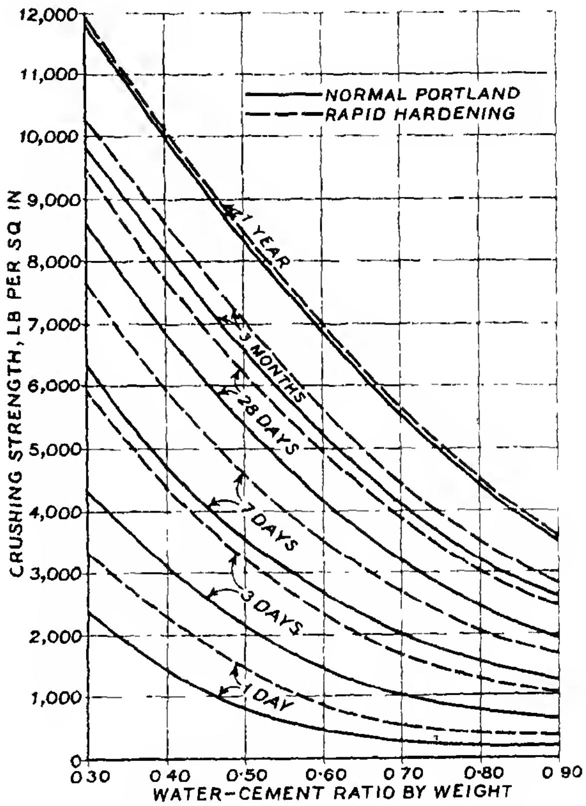


FIG. 1. GRAPH SHOWING RELATION BETWEEN CRUSHING STRENGTH AND WATER CEMENT RATIO

Maximum density is ensured by adopting a suitable grading of the aggregates, by using the minimum amount of water required to hydrate the cement and by employing mechanical means of compaction. High crushing strength is not necessarily obtained by increasing the proportion of cement but by reducing the water/cement ratio to the minimum required to ensure maximum density. A grading of aggregates which produces an unworkable concrete by hand ramming may be easy to compact by mechanical compaction and would have higher crushing strength resulting from the reduction of the water/cement ratio

* *See* F. N. Sparkes, "The Control of Concrete Quality," *Chem. Ind.*, vol. 57, 1938

The graph in Fig. 1 indicates the relation between crushing strength and water/cement ratio.

The crushing strength depends, in addition to the water/cement ratio, on the quality of the cement and aggregate, the age and curing of the concrete and the amount of compaction. The strength increases with age as indicated in Fig. 1. Curing is necessary to keep newly-mixed concrete in a damp condition and at a uniform temperature during as long a period as is practicable during its setting and hardening. If hardening and drying out are too rapid the concrete will be liable to crack and its density and strength will be reduced. Tests have proved that an increase of strength of 72 per cent can be obtained by adequate curing for ten days as compared with concrete allowed to dry out without any curing. Curing during the first hours after laying is the most important. A great advantage of mechanical compaction is that the concrete can be covered with damp hessian or waterproof paper at a much earlier time than the wetter hand-tamped concrete. The greater the cement content and the greater the water/cement ratio, the greater the risk of shrinkage, and therefore the more attention to adequate curing is required.

The water/cement ratio is the most important factor in determining the strength of concrete. The proportions of the aggregate and cement, and the type and grading of the aggregates, determine the water/cement ratio necessary to give the required workability. Unless the most rigid control of the proportioning of materials and water as well as of complete compaction is assured, it is inadvisable to rely upon securing the maximum strength that such rigid control might be expected to give. In the absence of entire confidence in the system of control it is necessary to allow a margin of safety for workability in determining the proportion of cement and the percentage of water. Mechanical compaction may be effected by the use of vibrating screeds. These are operated by hand, the vibration being achieved by means of electric motors, pneumatic hammers or a petrol-driven engine driving an eccentric shaft.

Alternative methods of vibration are:

1. Machines designed to run on the forms or rails and which are provided with vibrating beams.*
2. For walls, beams and structures where the use of screeds is impossible, external vibration applied to the shuttering or internal vibrating tubes inserted in the concrete.*

* See article on Road Making Plant and Machinery, p. 326

The advantages of mechanical compaction include:

1. The use of a lower water/cement ratio with consequent increase of strength or, alternatively, a reduction in the quantity of cement required to give any specified strength with resulting economy.
2. Economy in the cost of providing form support, since the forms or shuttering can be removed at shorter periods.
3. The risk of cracking is diminished by the reduction in cement and/or in water/cement ratio.
4. A denser and stronger concrete throughout the whole thickness of the slab.
5. Less risk of segregation.

Typical Variations in Strength of Concrete

During the construction of a housing estate road at Guildford a 4 in. thick base was laid of concrete containing 14 parts by weight of gravel and sand to 1 part cement with a water/cement ratio of 1·00, compacted by a pneumatically-vibrated screed. Tests at seven days gave an average crushing strength of 1,200 lb. sq. in. A 6 in. thick surface was laid of concrete containing 6 parts $\frac{3}{4}$ in. stone, 4 parts sand and 1 part cement, all by weight, with a water/cement ratio of 0·68 compacted by the same screed. Tests at seven days gave an average crushing strength of 2,200 lb. sq. in. A 6 in. thick surface was also laid of concrete containing 5 parts $\frac{3}{4}$ in. stone, $2\frac{1}{2}$ parts sand and 1 part cement all by weight with a water/cement ratio of 0·52 compacted by the same screed. Tests at seven days gave an average crushing strength of 3,400 lb. sq. in. None of the above mixes could have been properly compacted by hand-tamping unless the water/cement ratios had been increased, which would have resulted in a reduction of the crushing strength.

Hitherto in practice, test cubes made from concrete used in road works have shown a wide variation in crushing strength, due, no doubt, to some or all of the following causes: variations in the qualities of the cement, in the grading of the aggregates, the method of measuring the quantity of aggregates, the kind of mixer used, and the time of mixing. Further variations in the strength of the concrete after being laid may arise from the time interval between mixing and finishing, the method of placing or spreading, the degree of compaction, the lack of uniform density produced by the compacting tools and the efficiency of the curing.

CONTROL OF VARIATIONS

The strength of cores cut from concrete at the age of twenty-eight days also shows considerable variation Since the basis of design should be the minimum strength, and it is known that the maximum strength may be much greater than the minimum, it is important to control the variables with the object of reducing the margin between minimum and maximum to the utmost Such control may be secured by the following methods

Measurement of Specified Proportions

By measuring the specified proportions of aggregates, cement and water accurately and uniformly Weighing is preferable to volume measurement for the reason that the fine aggregate changes in volume with varying percentages of moisture content; provided that suitable equipment is used, the cost of measuring by weight is no greater and is quicker than by volume under the normal conditions of using a portable batch mixer of, say, ½ cu yd batch capacity The extra equipment required is a batch weighing machine capable of discharging the batch direct into the mixer, a pycnometer and a sensitive balance for ascertaining the specific gravity of the aggregates and the moisture content therein

The pycnometer consists of a glass jar of about 1 litre capacity, having a metal conical screw top with a ¼ in dia hole at its apex. The screw top must be watertight when it is screwed onto the jar and a rubber or fibre washer must be inserted in the joint. A suitable container may be made from a 2 lb fruit preserving jar of which the glass lid normally used is replaced by a sheet metal cone (see Fig 2). The balance should be designed to register weight not exceeding 3 kilograms and be accurate to 0·5 gramme The procedure for determination of the specific gravity is as follows. The pycnometer is filled with water until it reaches the top of the hole in the apex of the cone The pycnometer is then dried on the outside and weighed. The temperature (T) of the water in the pycnometer is taken The aggregate is dried and 1,000 grammes of the dry material weighed up The pycnometer is then filled with water to approximately one-third of its capacity and the aggregate poured in, extra water being added as required to ensure that the material is kept thoroughly saturated. The pycnometer is next filled with water up to the level of the hole in the cone as before and all air and froth eliminated by tapping the sides. The pycnometer is then dried on the outside and weighed. The temperature of the water in the pycnometer must not differ from the former temperature (T) by more than 2° C (3·6°F). The approximate specific gravity of the aggregate may be calculated from the formula .

$$G = \frac{S}{S - (W - P)}$$

where G is specific gravity, S = 1,000 grammes, W = weight of pycnometer filled with aggregate and water and P = weight of pycnometer filled with water

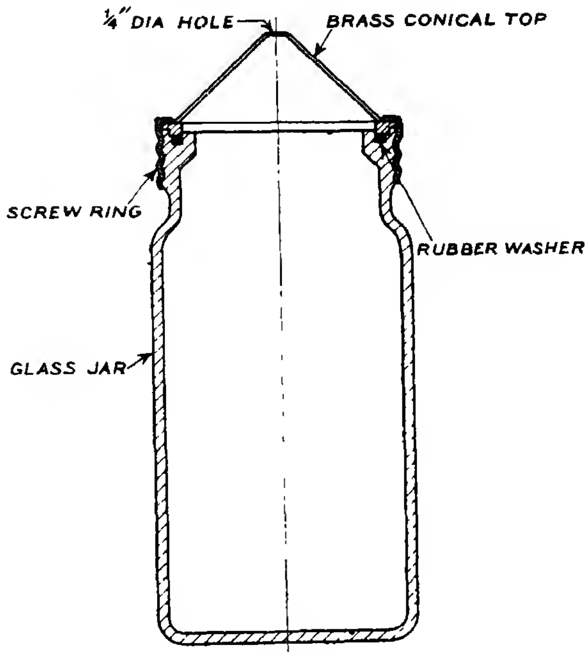


Fig. 2 Fruit Preserving Jar Adapted for use as a Pycnometer

Determination of Moisture Content

The procedure for determination of the moisture content of the aggregates is as follows

Place 1,000 grammes (S) of moist aggregate in the pycnometer in place of the dry material used in the above operation for specific gravity Proceed as above and ascertain the weight of the pycnometer filled with the 1,000 grammes of moist aggregate and water (weight = W_1). The moisture content M_D as a percentage of the dry material may be calculated from the formula

$$M_D = \left(\frac{100 S\,(G-1)}{(W_1 - P)\,G}\right) - 100 \text{ where } S = 1{,}000$$

If the moisture content is required as a percentage of the wet aggregate it may be calculated from the formula

$$M_W = 100 - \left(\frac{100 G\,(W_1 - P)}{S\,(G-1)}\right) \text{where } S = 1{,}000.$$

The time occupied in carrying out the determination of either the specific gravity or the moisture content by an intelligent and careful operator should not exceed from five to seven minutes

If, in practice, the same aggregates are used throughout the work, the specific gravity is ascertained once only, and the subsequent field tests for moisture content are simplified if a table is prepared beforehand and supplied to the operator A sample table might be as under shown in Table I.

PYCNOMETER TEST

Job Construction of 6 in concrete carriageway
Job No 28/122
Aggregates: Coarse ¾ in — $\frac{3}{16}$ in G 2·58 Fine $\frac{3}{16}$ in down $G = 2{\cdot}65$
Mix proportions 1 : 2½ : 5 by weight
Dry batch weights Coarse 560 lb. Fine 280 lb
Cement 112 lb
Water/cement ratio 0·52 Total quantity of water per batch 5·8 gal

As an example of the use of Table I, assume that the operator finds that the recorded weight of the pycnometer + moist aggregate (coarse) = 2,198½ grammes He refers to the table and reading along the line beginning 2,198½ he reads off 4 per cent moisture content = 2·2 gallons per batch, and weight of water in batch 22 lb. Similarly, if the recorded weight of the pycnometer + moist aggregate (fine) = 2,197 grammes, he reads off opposite 2,197, 6 per cent moisture content = 1·7 gallons per batch and weight of water in batch 17 lb The total amount of water in coarse and fine aggregates is 22 + 17 = 39 lb The required water/cement ratio being 0·52, the total quantity of water per batch is 58 lb., therefore, the difference between 58 and 39 lb = 19 lb is the amount of water required to be added to that batch It is necessary to make the test each day before starting mixing and repeat at, say, three-hourly intervals or whenever a change in weather conditions likely to affect the moisture content of the aggregates occurs

Other methods of measuring the moisture content are available, such as drying out and ascertaining the difference between dry and wet weights, washing with alcohol, and some patented methods, but the pycnometer method has been proved, in practice, to be sufficiently accurate and is reliable and expeditious

Control of Aggregates

Control over the grading of the aggregates is important in order to ensure uniformity in workability This is attained by dividing the aggregates into as large a number of separate clean sizes as practicable and weighing each separate size, allowing for moisture content In the foregoing example the coarse aggregate is indicated as ¾ – $\frac{3}{16}$ in, in practice this might be made up of ¾ in clean, ½ in clean and ⅜ – $\frac{3}{16}$ in., each size delivered separately and mixed in the proportions found to give the easiest workability with the minimum of water The quantity of each size required should be measured by weight on the batch weigher

Quality of Cement

Control over the quantity and quality of the cement used is achieved by adequate attention to storage and protection on the site and by weighing on the batch weigher in preference to measure-

Table I—FIELD TESTS FOR MOISTURE CONTENTS

Coarse Aggregate				*Fine Aggregate*			
Weight of Pycnometer + Aggregate + Water	*Percentage of Moisture*	*Weight of Aggregate per Batch*	*Quantity of Water in Aggregate per Batch*	*Weight of Pycnometer + Sand + Water*	*Percentage of Moisture*	*Weight of Aggregate per Batch*	*Quantity of Water in Aggregate per Batch*
grm		*cwt. qrs lb*	*gal.*	*grm*		*cwt qrs lb*	*gal*
2,222½	0	5 0 0	0·0	2,232½	0	2 2 0	0·0
2,216½	1	5 0 6	0·6	2,226½	1	2 2 3	0·3
2,210½	2	5 0 11	1·1	2,220½	2	2 2 6	0·6
2,204½	3	5 0 17	1·7	2,214½	3	2 2 8	0·8
2,198½	4	5 0 22	2·2	2,209	4	2 2 11	1·1
2,192½	5	5 1 0	2·8	2,203	5	2 2 14	1·4
				2,197	6	2 2 17	1·7
				2,191½	7	2 2 20	2·0
				2,186½	8	2 2 22	2·2
				2,181	9	2 2 25	2·5
				2,176	10	2 3 0	2·8

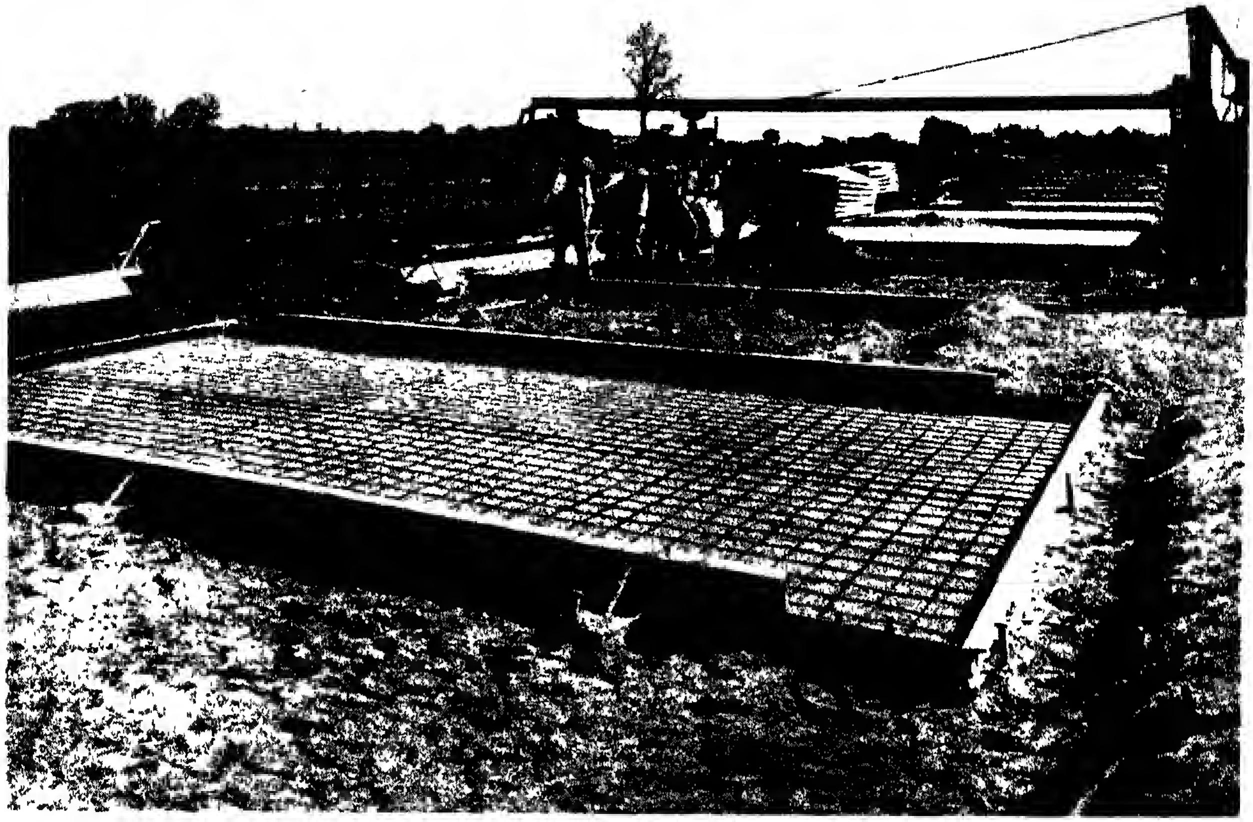


FIG. 3—A SECTION OF THE ALTHORPE BY-PASS IN COURSE OF CONSTRUCTION
(Twisteel Reinforcement, Ltd.)

ment by volume Frequent tests of the cement for quality are necessary, as variations may account for large variations in the strength of the concrete

CONTROL OF MIXING OPERATIONS

Mechanical mixing allows closer control than hand mixing Mechanical mixers are described in the article on Road-making Plant and Machinery, page 323. Control of such mixers is necessary to obtain uniformity of mix in the following respects.

1 The mixer drum should have ample capacity for the batch of weighed aggregate and cement.
2 The loading hopper should discharge the batch into the drum without spill, and completely empty itself without having to be bumped or shaken
3. The period of mixing time in the drum should be great enough to produce the best mix. A standard performance test for mixing is urgently required and will, it is hoped, be available in the near future.
4 The drum must be kept clean internally.
5 Fittings for accurately controlling the amount of water to be added in the drum should be provided to enable any prescribed amount of water to be used and, if necessary, varied for each batch. A small variation in the quantity of water may result in a variation in the water/cement ratio with consequent variation in strength (see Fig. 1, page 171). Control is facilitated by using large batches, say, 1 or 2 cu yd , the quantity of water per batch being larger, inaccuracy in measuring should be reduced On smaller capacity mixers, accuracy may be obtained by the use of a two-gallon bucket graduated to measure to half a pint, or by the use of a metal tank, the height dimension of which is greater than the diameter, which should be kept as small as practicable The tank should be fitted with a sight level gauge graduated to read to half a pint.

Curing

The time interval between the completion of the compaction and the covering of the concrete should be kept to the minimum Mechanical compaction and low water/cement ratios assist in reducing this interval as the layer of waterproof paper to retain the moisture may be applied immediately. If the curing layer is other than waterproof paper, the material, e g hessian, or soil, must be laid as soon as the concrete is hard enough and must be kept damp continuously for ten days During the period between the compaction and the application of the curing medium, the surface should be protected from sun and wind by tenting. Protection of the concrete during the first three hours after laying is more important than subsequently and all practical steps should be taken to ensure uniformity in time of application and of the waterproof quality of the material used The three principal methods of curing are (1) by covering with waterproof paper or bituminous dressing, (2) by covering with damp hessian, matting, straw, sand or soil, and, (3) by chemical treatment, i e the addition of calcium chloride to the concrete mix or in the mixing water or by spreading calcium chloride at the rate of 1 lb per sq. yd on the surface of the concrete after the initial curing during setting has been completed

STEEL REINFORCEMENT

There appears to be a difference of opinion amongst highway engineers as to the need for steel reinforcement in concrete for use in the construction of roads The Ministry of Transport (Roads Department) has hitherto often required the use of two layers, each layer to weigh not less than 7 lb /sq. yd.

A decision in any particular case would depend on several factors, including bearing power of sub-soil, thickness and length of slab, variation in atmospheric temperature range, spacing of expansion joints and probability of uneven settlement in the sub-soil. If the concrete slabs in a road were laid on a stable foundation, sufficient joints were provided to deal with expansion and contraction, the control of the quality of the concrete were of high degree and the workmanship during placing, compacting and curing were of the best quality, then the use of steel reinforcement would be redundant.

The use of steel reinforcement will not prevent cracking but may prolong the life of the concrete by reducing the injurious consequences of cracking and will provide a means of controlling crack development In an experimental concrete road laid at Harmondsworth in 1930, the 8 in. thick concrete slabs laid in bays 30 ft long on 3 in. rolled clinker have been carefully surveyed for crack development. The survey showed that forty-four slabs un-reinforced showed a greater length of cracking and wider cracks than the reinforced slabs Comparison of slabs laid on waterproof paper shows that the amount of cracking is greatest for wet concrete and least for dry concrete; it therefore seems likely that on a clinker foundation better results are obtainable with a mix appreciably drier than that normally used To what extent the cracking has been caused by stresses due to settlement on the foundations does not appear to have been determined

On the Farnham By-Pass in the county of Surrey which was constructed in 1939 40 the 8 in thick concrete slabs were un-reinforced The slabs were laid in bays 80 ft long with dummy joints at 20 ft. intervals (concrete 1 · $2\frac{1}{2}$ 5 by weight) on about 5 ft filling of sandy soil The filling was compacted by the passage of 8 cu yd Le Tourneau Scrapers A sub-base 4 in thick of stabilized soil using cement as the binder was laid on the filling before laying the surface slabs Cracking has taken place at the dummy joints as was anticipated At a survey made in June 1945, 53 per cent of the slabs were uncracked Those 20 ft slabs which were cracked showed the cracks occurring chiefly about the middle of the slab and the cracks were probably caused by the combined effect of traffic and temperature changes, as the traffic consisted of heavy military vehicles, including heavy tanks

CONCRETE SLABS

The normal practice in Surrey prior to 1939 for the construction of new concrete carriageways was to lay the bays longitudinally 90 to 100 ft. in length, 11 to 12 ft. wide, 6 to 8 in thick on a sub-base of 4 in thick stabilized soil, with dummy joints at about 30 ft intervals The expansion joints at the ends of the slabs were formed by the insertion of a vertical strip of fibre expansion jointing $\frac{3}{4}$ in. thick and 1 in less in depth than the thickness of the slab. The dummy joints were formed by the insertion of a 2 × $\frac{1}{4}$ in timber strip, set on edge on the sub-base which was covered with a layer of tarred paper The cracks occurring at the dummy joints show on the surface as an irregular line and, consequently, are more difficult to seal than straight line cracks. It

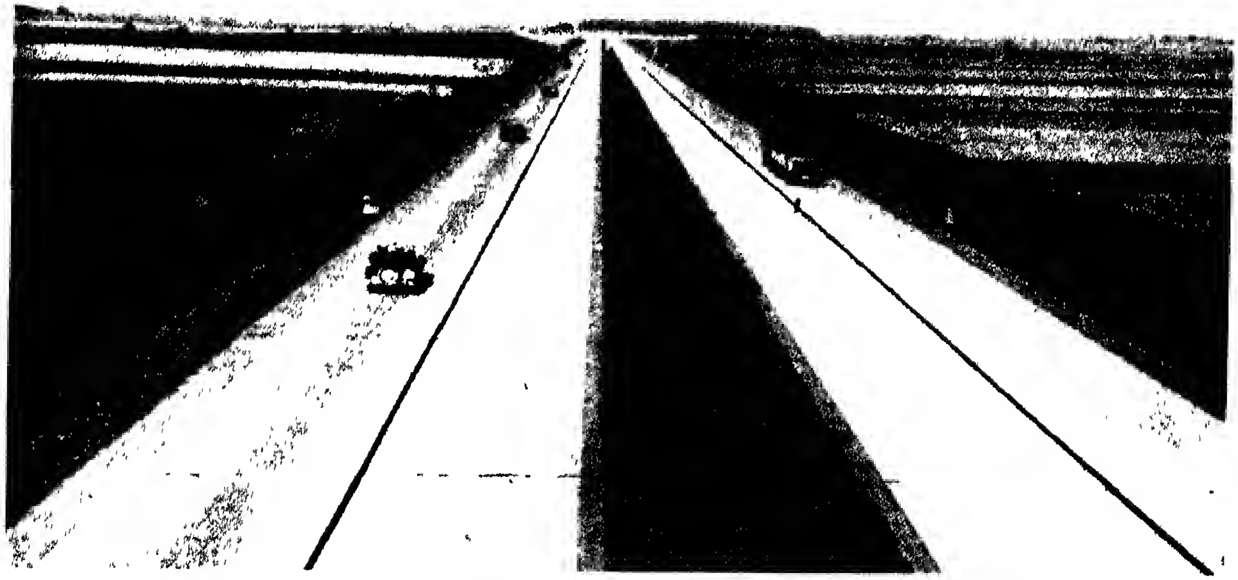


FIG. 5.—BITUMINOUS BOARD USED AS EXPANSION JOINTING MATERIAL FOR A CONCRETE ROAD
(*Lloyd Boards, Ltd.*)

is therefore better practice to place the timber strip at surface level.

The reason for laying the timber laths forming the dummy joints at the sub-base and not at surface level was that all the concrete was compacted by a vibrating machine which compacted the concrete to such a density that it was impossible to insert the timber strip after the concrete was laid. This difficulty may be overcome by the use of a prefabricated joint laid before spreading and compacting the bulk of the concrete (see Fig. 4).

In 1932–33 about 1½ miles of concrete carriageway 30 ft. wide were laid 8 in. thick on a good gravel sub-soil in bays 20 and 30 ft. long, experimenting with various types of joints, details of which are shown in the Report of the Technical Advisory Committee (Roads) to the Ministry of Transport under the title of "Concrete in Road Construction", published by H.M. Stationery Office in 1933.

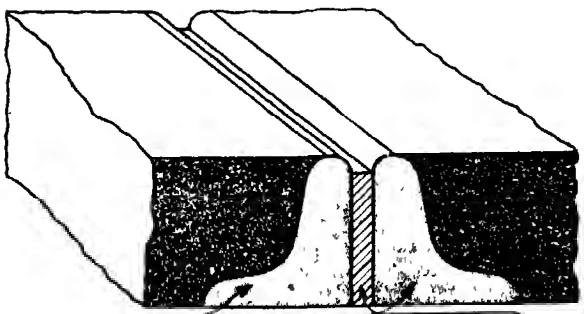


FIG. 4.—PREFABRICATED JOINT FOR CONCRETE ROADS

At the time of writing (1946) this road is in excellent condition, being almost free from cracking and spalling at the joints. The vertical butt joint, the cheapest to construct, appears to be in as good condition as the more elaborate and expensive types, which is largely due to the stable base on which the slabs were laid.

The joints in a concrete road are the least satisfactory part of the design but are essential to obviate damage by expansion and contraction.* Concrete roads have been constructed with plain butt joints at intervals of about 15 ft., no other

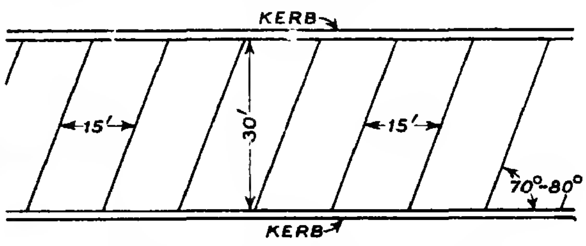


FIG. 6.—PLAIN BUTT JOINTING OF CONCRETE SLABS ARRANGED TO INDUCE GREATER EXPANSION TRANSVERSELY

* See article on Expansion and Contraction Joints in Concrete Roads, page 186.

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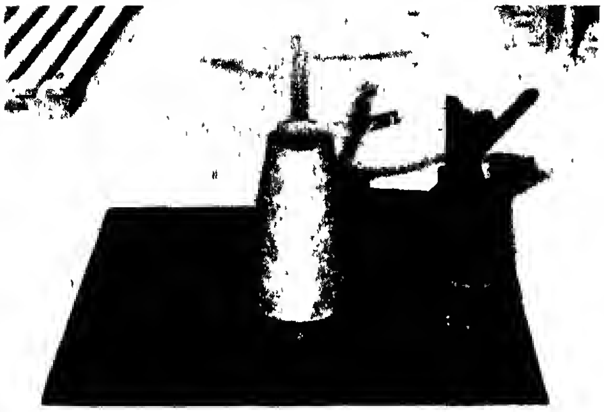
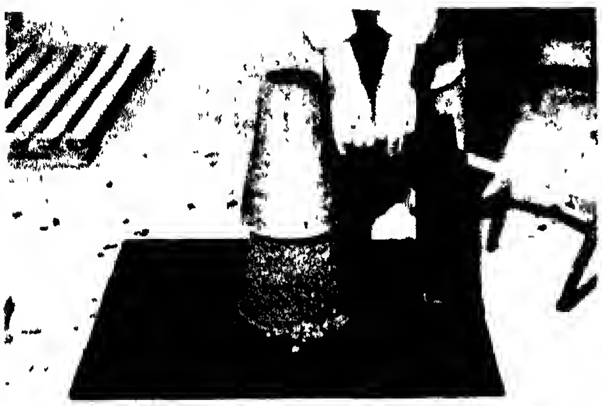
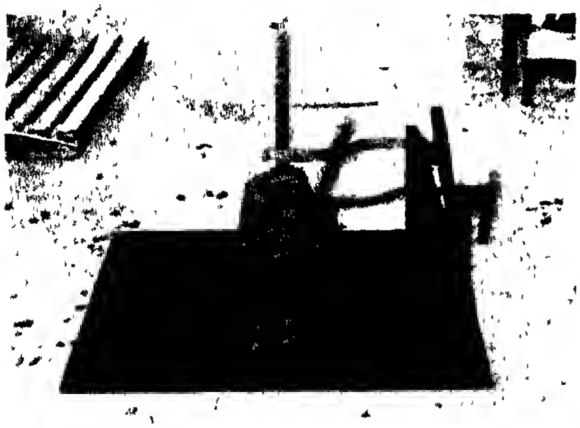


(*a*) Mould into which concrete is placed



(*b*) Removing mould after it has been filled with concrete



(*c*) Cone of concrete after mould has been removed.

FIG. 7.—SLUMP TEST FOR CONCRETE

(*Cement & Concrete Association*)

expansion joints being provided, but the design of the slabs was such as to induce the greater expansion transversely as indicated in Fig. 6. This design does not lend itself easily to compaction of the concrete by vibrating machine and is laid on the alternate bay method, each joint being painted with a bituminous paint. As water is certain to find its way through the joints, it is recommended that the slabs should be laid on a sub-base of stabilized soil or lean concrete, which will waterproof the formation and decrease the deflection under load at the ends of each slab. The provision of the sub-base should permit a reduction in the thickness of the slab for surfacing.

In 1943 a new road was constructed having a sub-base of stabilized soil 8 in. thick (sixteen parts soil to one part cement by weight) and a surfacing 3 in. thick of $1 : 2\frac{1}{2} : 5$ concrete laid without any expansion joints. After two years' use by heavy lorry traffic, during which several fine contraction cracks appeared, the road is in excellent condition. The cracks have been recently sealed by the application of a surface dressing of bituminous material.

Further research and full-scale experiment and trial are urgently desirable to assist in determining the minimum thickness of the layers for any particular class of sub-grade and the minimum strength of the concrete to resist attrition by traffic and temperature changes.

TESTS FOR MATERIALS

Reference to the British Standard Specifications listed in Appendix No. 1, will provide information with regard to the testing of materials used on highway work and the standard methods recommended for such tests. The tests enumerated below do not appear in those Specifications and it is hoped standard methods will be drawn up.

SLUMP TEST FOR WORKABILITY OF CONCRETE

This test is no guide to the water/cement ratio but is a useful guide as to workability. It is included in the Report of the Reinforced Concrete Structures Committee of the Building Research Board with recommendations for a Code of Practice for the use of Reinforced Concrete in Buildings (H.M. Stationery Office). The apparatus consists of a metal conical mould 12 in. high, 8 in. diameter at bottom, 4 in. diameter at top, a steel punning rod of $\frac{5}{8}$ in. diameter, and a steel base plate on which to stand the mould (see Fig. 7). The mould is filled with the concrete in four layers, each layer to be rammed twenty-five times with the punner.

Compacting Factor Apparatus

As a substitute for the slump test, a compacting factor apparatus has been designed by the Department of Scientific and Industrial Research, to measure the workability of concrete (see Fig 8) The apparatus measures the amount of compaction produced by a standard amount of energy applied by dropping the concrete from a series of two hoppers into the cylinder below The concrete is then struck off level with the top of the cylinder by means of two floats The compacting factor is defined as the ratio obtained by dividing the weight of the wet concrete in the cylinder by the weight of that quantity of fully compacted concrete which is required to fill the cylinder

Moisture Content of Concrete Aggregates

The pycnometer method is fully described on page 173.

Efficiency of Mixing Cement with Aggregates

No standard method of testing the performance of machine mixers has yet been issued but it is hoped that one will be designed in the near future by the Road Research Laboratory

Resistance of Concrete to Abrasion

A method of testing and a machine for carrying out the test has been evolved by the Road Research Laboratory, and the machine is illustrated in Fig 9

Crushing Strength of Concrete

Although standard methods of testing for crushing are issued for freshly mixed concrete and for cores cut out of the completed work, a method of determining the crushing strength of completed concrete in situ at the age of twenty-four hours is urgently required to avoid the expense and the uncertainty of result of cutting out cores, which may not be fully representative of the whole mass

Cement

Table VI, page 184, provides a summary of British Standards for cement.

Reference should be made to the standard methods of testing tar, bitumen and aggregates for concrete and bituminous macadam included in the relevent British Standard Specifications

LABORATORY EQUIPMENT

Every large Highway Authority should be provided with a laboratory (centrally situated) and a mobile field laboratory. The central laboratory should include the following necessary equipment as a minimum.

Fig. 8 - Compacting Factor Apparatus
(*Reproduced by permission of the Director of Road Research Crown Copyright reserved*)

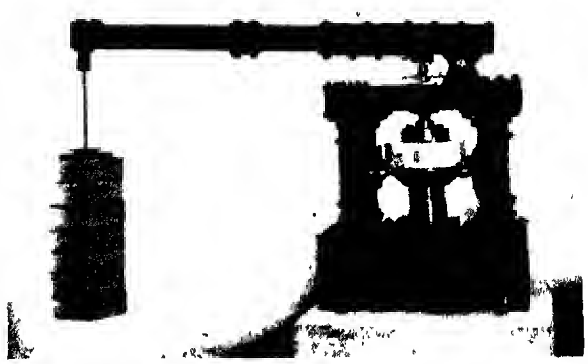


Fig. 9 Tank Wear Testing Machine
(*By permission of the Director of Road Research Crown Copyright reserved*)

One set of standard sieves

A pycnometer and balance to weigh 7 kg., accurate to 0 5 grammes.

For testing cements, 6 briquette moulds, 1 testing machine for breaking under tension standard 1 : 3 mortar briquettes, and the apparatus for carrying out the Le Chatelier test

For testing concrete, 12 standard steel 6 in cube moulds, and the standard punner for ramming the concrete in the moulds

Apparatus for extracting bitumen and tar from mixes.

Viscometer

Drying oven

Apparatus for determining the moisture content at which the maximum density of soil is obtained, consisting of a brass mould 4 in. diameter and 4·6 in high with detachable collar and base, standard rammer, and aluminium containers

Apparatus for determining the California bearing ratio of soils

Apparatus for measuring the bulk density of soil

Auger for taking out cylindrical samples of soils

Beakers, thermometers, chemicals, temperature control, water supply, curing tanks, etc.

The mobile laboratory is usually equipped to deal with soil surveys as well as testing of materials Table VII on page 39 of the article on Preliminary Surveys gives some indication of the type of equipment required. The following additional items are the minimum possible for testing of materials for concrete (*a*) Set of standard sieves, (*b*) pycnometer and balance, (*c*) cement briquette moulds and testing machine; (*d*) standard steel moulds for concrete compression tests and standard punner for filling same; (*e*) apparatus for determining moisture content and bulk density as described above.

SPECIAL SURFACING MATERIALS

Mastic Asphalt*

Mastic asphalt is a mixture of asphaltic cement with a mineral aggregate finely ground. (See B.S. 596 . 1945) There are many and various types of mixture using different bitumens and mineral aggregates in various proportions The mastic is usually manufactured and delivered in blocks, which are melted in a cooker fitted with stirring apparatus. When heated the material should be capable of being worked without difficulty, by spreading, usually about 1¼ to 2 in. thick.

* See article on Asphalt Roads, page 189.

Sett Paving†

Setts are used where there is a preponderance of horse-drawn traffic and on steep gradients to provide foothold They may be of granite, whinstone, or gritstone, ranging in size as to width from 3 to 4 in , depth from 5 to 7 in , and length from 5 to 7 in The setts may be laid on a bed of sand or on a concrete foundation, the joints being filled with sand, chippings, cement mortar or bituminous material Stone setts have been extensively used for paving the channels of, and to form abutments for, macadam carriageways and at the joints of concrete and macadam pavings

Tar Carpets

This type of surfacing has been developed considerably during the war years, and has been fully dealt with in the articles on "Coated Macadam" and "Maintenance of Highways", pages 193 and 407

Wood Paving‡

Wood paving is extensively used in preference to granite setts for streets carrying heavy traffic where the minimum of noise, as well as durability is required Wood blocks may be of either hard or soft woods, the latter appear to be preferred as being less slippery, more uniform in quality and wear and less brittle at the edges

As considerable expansion and contraction occur, expansion joints of clay or bituminous material should be provided contiguous to and parallel with the kerbs The blocks should be laid direct on the concrete foundations and not on to a thin floating of cement mortar, which will crack and cause movement under heavy traffic. For maintenance the wood blocks should be surface dressed with a hot bituminous material to seal the surface and joints from the ingress of water To counteract any tendency towards slipperiness, it is usual to spread small gravel, which becomes embedded in the wood under the action of traffic.

Rubber§

Rubber has not been extensively used for paving owing to its high cost It has been used, however, for traffic guide lines, coloured marking blocks, cat's eye reflectors, etc , and experimental sections of thin rubber carpets have been tried. In addition to the high cost, it is difficult to provide a non-skid surface now that traffic is

† See article on Natural Stone Kerb and Setts, page 201

‡ See also article on Wood Paving, page 203.

§ See also article on Rubber Paving, page 209.

(*a*) Spreading top layer of stones over the mortar

(*b*) Completion of rolling, tamping out wheel marks and other irregularities and giving final brushing to fill up any raw places

Fig. 10.—Cement Bound Road at Edge Lane, Liverpool

(*Cement & Concrete Association*)

almost entirely on rubber tyres. Prior to the war, research work was undertaken to ascertain the advantage of mixing colloidal rubber with tar and bitumen with the object of improving the binding quality. It is to be hoped that such research will now be resumed. Spongy rubber has been used for filling expansion joints in concrete roads and, provided the cost is reasonable and its durability is equal to other materials, its use for that purpose will no doubt increase.

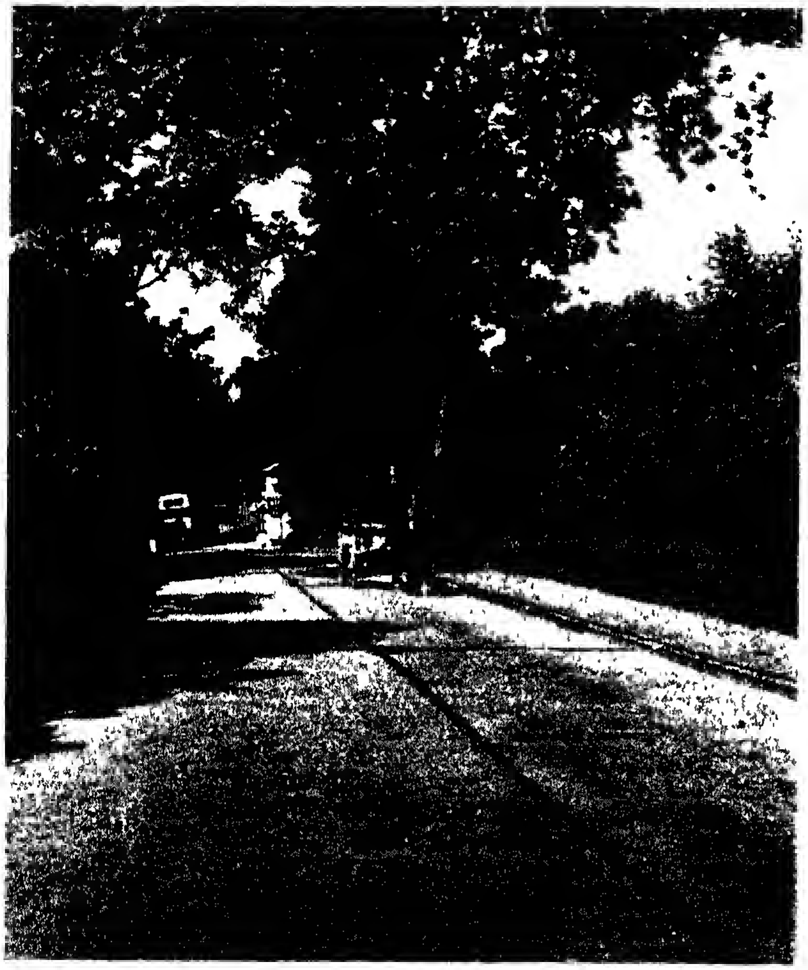


FIG. 11.—CEMENT BOUND ROAD
(*Cement & Concrete Association*)

MACADAMIZED CONCRETE. ("Sandwich" Concrete Road or Rolled Concrete)

This consists of a layer of 2 in. aggregate laid to a consolidated thickness of approximately 2½–3 in. and lightly rolled. On this is placed a stiff cement mortar (2 : 1 sand and cement) 2 in. thick. A top layer is then placed thereon similar to the bottom layer and the whole rolled with a 10-ton roller. As the mortar appears on the surface it should be brushed over the stone, any low spots being made up with slightly smaller aggregate. Rolling should continue until mortar appears on the surface over the whole area. It is desirable to cure in the ordinary way. Surfacing of this type is illustrated in Figs. 10 and 11.

FLAGS*

The paving of footways in shopping and residential roads may be of natural or artificial stone, from 2 to 2½ in. thick and of standard dimensions (see B.S. 368: 1936), laid on a foundation of sand, gravel, hardcore, cement mortar or concrete or stabilized soil, the joints being filled with either cement mortar or a bituminous material. Natural stone flags should be of hard-wearing stone, free from laminations and providing a non-slip surface. Artificial stone flags should possess the above qualities and comply with the requirements of B.S. 368. Flag paving is usually more expensive than other materials but possesses the advantages of economy in maintenance and facility in reinstatement.

BRICKS

Although not used in the British Isles to any appreciable extent for surfacing carriageways, bricks have been used for paving footways, and in Holland for paving carriageways. If bricks are used for carriageways, they should be uniform in quality, sufficiently hard to withstand the attrition and abrasion of traffic and should be laid on a sufficient foundation. Joints should be filled with cement mortar or a grouting of bituminous material. Bricks for footway paving should be hard-wearing, non-slippery and of uniform quality laid on a foundation of sand, concrete, hardcore or stabilized soil. The use of bricks for paving has probably fallen into disfavour owing to the introduction of artificial stone flags for footways and concrete for carriageways.

* See also article on Natural Stone Kerb and Setts, page 201.

USEFUL TABLES AND DATA

TABLE II

SECTIONAL AREAS AND WEIGHTS PER LINEAL FOOT OF ROUND STEEL BARS

Diameter in inches	*Area sq inches*	*Weight* per foot in lb*	*Number of feet to 1 ton*
1/8	0·012	0·041	51,631
3/16	0·027	0·092	21,347
1/4	0·049	0·167	12,815
5/16	0·076	0·258	8,682
3/8	0·108	0·376	5 957
1/2	0·196	0·668	3,353
5/8	0·304	1·043	2 148
3/4	0·441	1·502	1 491
7/8	0·601	2·044	1 096
1	0·785	2·670	838
1 1/8	0·994	3·380	663
1 1/4	1·227	4·172	537
1 3/8	1·485	5·049	443
1 1/2	1·767	6·008	373
1 3/4	2·406	8·178	271
2	3·143	10·680	206

* *The above weights are based on the weight of steel as being* 490 *lb per cu ft*

TABLE IV

SPECIFIC GRAVITY OF VARIOUS ROCKS

Sedimentary Rocks	
Sandstone	2·45 to 2·70
Greywacke	2·70
Dolomite	2·70 to 2·80
Quartzite	2·47 to 2·68
Limestone	2·43 to 2·71
Flint and chert	2·60
Igneous Rocks	
Granite	2·65
Felsite	2·65
Diorite	2·83
Gabbro	2·95
Porphyry	2·65 to 2·75
Syenite	2·73
Andesite	2·73
Dolerite and basalt	2·90

TABLE V

BRITISH AND AMERICAN STANDARD SIEVE SIZES IN COMMON USE

British*. 1½ in, ¾ in, ⅜ in, 3/16 in, Nos. 7, 14, 25, 52, 100, 200
American: 1½ in., ¾ in, ⅜ in., Nos. 4, 8, 16, 30, 50, 100, 200

*See B S. 410 1943.

TABLE III

APPROXIMATE WEIGHTS OF VARIOUS MATERIALS

	lb per cu ft
Normal Portland cement	90
Rapid hardening cement	81
Asphalt	144
Ballast and sand, loose dry	90–106
Bitumen	62
Pressed brick	150
Common brick	125
Brickwork	115
Chalk	112
Clay, loose	63
Clay, solid	125
Concrete	
Gravel aggregate	150
Reinforced	150
Breeze	110
Foam slag	75
Bramley fall stone	150
Gravel	100
Gravel and sand	110
Granite	165
Limestone	160
Quicklime	55
Masonry	
Rubble	140
Ashlar	140–150
Pitch	72
Portland stone	145
Purbeck stone	162
Quartz	166
Sand (river) dry	95–105
Sandstone	145
Slate	160–180
Tar (coal)	63–70
Whinstone	172
Stone paving (York)	145–155
Concrete paving	130–135
Timber (dry)	
Ash	50
Beech	51
Elm	40
Fir	30
Greenheart	60
Jarrah	51
Larch	35
Oak (English)	50
„ (Baltic)	46
Pine (Memel)	36
„ (American)	36
„ (Pitch)	50
„ (Kauri)	38
Teak	45–60
Iron (wrought)	480
„ (cast)	450
Steel (mild)	490

TABLE VI

BRITISH STANDARDS FOR CEMENT

Fineness

Ordinary Portland not more than 10% retained on 170 sieve
Rapid hardening „ „ „ 5% „ „ „ „
High alumina „ „ „ 8% „ „ „ „

Tensile Strength

Tests made on 1 3 mortar briquettes
Ordinary Portland. 300 lb sq in at 3 days and 375 lb sq in at 7 days
Rapid hardening 300 lb sq in at 1 day and 450 lb sq in at 3 days
High alumina—not included in British Standard.

Compressive Strength

Tests made on 1 3 mortar cubes, water/cement ratio 0 40
Ordinary Portland 1,600 lb sq in at 3 days—2,500 lb sq in at 7 days
Rapid hardening 1,600 lb sq in at 1 day—3,500 lb. sq in at 3 days
High alumina 6,000 lb sq in at 1 day—7,000 lb sq. in at 3 days

Setting Time

Type of Cement	*Initial not less than*	*Final not more than*
Ordinary Portland	30 mins	10 hours
Rapid hardening	30 „	10 „
Quick setting	5 „	30 mins
High alumina	Not less than 2 hrs or more than 6 hrs	Not more than 2 hrs after the initial set

Soundness

Type of Cement	*Expansion after 3 hours' boiling to be not more than*
Ordinary Portland	10 mm (or 5 mm after 7 days' aeration)
Rapid hardening	10 mm (or 5 mm after 7 days' aeration)
High alumina	1 mm

APPENDIX No 1

LIST OF BRITISH STANDARD SPECIFICATIONS REFERRING TO ROAD CONSTRUCTION

		No	
AGGREGATES	Clinker for concrete	1,165	1944
	Blast-furnace slag	1,047	1942
	Foamed slag	877	1939
	Natural for concrete	882	1944
	Sampling and testing	812	1943
ASPHALT	Single coat	510	1933
	Double „	511	1933
	Compressed rock	348	1945
	Rolled	1,152	1944
	Cold with emulsion	433	1931
	Penetration method	347	1928
	Hot mastic with fluxed lake bitumen	596	1945
	Hot mastic with fluxed natural bitumen	597	1935
BITUMEN	Fluxed lake and asphaltic	594	1945
	Fluxed natural asphaltic	595	1935
	Mixtures—sampling	598	1940
	Emulsion	434	1935
BRICKS	Common building	657	1941
	Sand lime	187	1942
BRIDGES	High tensile steel for	548	1934
	Steel	15	1936
CEMENT	Portland	12	1940
	High alumina	915	1940
CHANNELS	Granite and whinstone	435	1931
	Precast concrete	340	1936
	Sandstone	706	1936
CONCRETE	Slabs	1,020	1942
	Natural aggregates for concrete mixers	882	1944
	Flags	368	1936
	Pipes, unreinforced	556	1945
	Kerbs	340	1936
	Sampling and testing aggregates	812	1943

(Continued on page 185)

APPENDIX No I—(contd)

LIST OF BRITISH STANDARD SPECIFICATIONS REFERRING TO ROAD CONSTRUCTION

		No
CREOSOTE	For timber	144 1936
COAL TAR	Sampling	616 1938
	Tars	76 1943
	Tar emulsion	618 1935
DRAINS	Fittings for	1,130 1943 and 539 1937
	Pipes	437 1933 540 1937 and 65 1937
	Manhole covers and frames	497 1933
EXPANDED METAL	Steel	405 1945
GIRDER BRIDGES	Construction details	153 Parts 1 & 2 1933 and Parts 3, 4 & 5 1937
KERBS	Concrete	340 1936
	Granite and whinstone	435 1931
	Sandstone	706 1936
MACADAM.	Tarmacadam	802 1945 Part 1 Granite Limestone and Slag Aggregate, Part 2 Surfacing
	Asphalt (emulsion) (See also asphalt)	434 1935
	Sizes of stone and chippings	63 1913
REINFORCEMENT	Steel bars twisted	1,144 1943
	,, ,, rolled and hard drawn	785 1938
	Expanded metal	405 1945
STEEL	Rolled steel joists (see also Reinforcement)	4 1932
	Steel for bridges	15 1936
	High tensile for bridges	548 1934
SETTS	Granite and whinstone	435 1931
	Sandstone	706 1936
SIEVES (TEST)	410 1943, 318 1945, 594 1945, 595 1935, 596 1945, 597 1935, 12 1940, 146 1941 and	481 1933
STONES	Sizes (See also Aggregates)	63 1939
SIGNS	Road traffic (cast metal)	873 1939

NOTE *The above list is not comprehensive, there are Standard Specifications for materials, such as paint, oils, etc, particulars of which may be obtained from the British Standards Institution, 28, Victoria Street, London, S.W.1*

EXPANSION AND CONTRACTION JOINTS IN CONCRETE ROADS

By R. G. H. SALMON

Expansion joints are still to-day sometimes regarded as a "necessary evil." Specifications regarding the materials and their installation are often vague and indeterminate. This almost invariably results in badly constructed joints with inferior materials which probably cause cracking, spalling, disintegration and subsidence. Sooner or later patches of tarmac are necessary, usually followed by a complete carpet, and the road, as a concrete road, is a failure.

Expansion joints are the "weak link" in concrete roads and, as such, should receive due care and attention on the part of the designer. Any amount of care over specifications for the subgrade, drainage, aggregate, mixing, placing and consolidating, may prove wasted energy if the same specifications do not give due care and attention to expansion joints. The difference in cost between inferior materials and those which will give long service combined with good appearance, is not more than one-half of 1 per cent of the cost of the road.

The following are a few faults which can arise from badly-made joints.

Water Seepage.

Water seeping through joints may cause subsidence by washing away the subgrade. Frost and ice will result in cracking and spalling.

Grit and Loose Stones.

Inefficiently sealed joints may become packed at the top with grit and small stones. Surface spalling and disintegration will be the result. (See Fig. 1*d*.)

Joints not vertical.

Sloping joints will cause one slab to ride up on the other when expansion takes place. (See Fig. 1*a*.)

Joints not extending the full depth of slab.

Results, disintegration at bottom of slabs with probable subsidence. (See Fig. 1*c*.)

EXPANSION OF THE SLABS AND SPACING OF JOINTS

Thermal Movement.—Although the change in length of a slab is influenced by other factors, the primary consideration must, of course, be temperature variation. The average coefficient of thermal expansion of concrete in road construction is accepted as 0.0000055 ft. per foot length per degree F. The range of mean temperatures of a road slab, in a temperate climate such as the British Isles, is considered to be about 75°F.

The expansion caused by temperature variation in a 100 ft. road slab will therefore be

$$0.0000055 \times 75 \times 100 \times 12 = 0.5 \text{ in.}$$

Moisture Movement.—A concrete slab will increase in length when supplied with moisture and decrease in length when deprived of it. Although the quality and density of the concrete influence the moisture movement, records taken over a period of years show that the movement is about $\frac{1}{8}$ to $\frac{1}{4}$ in. in 100 ft.

Although maximum temperature and moisture conditions may not occur together provision must be made for this contingency, therefore—*the minimum allowance should be $\frac{3}{4}$ in. per 100 ft.*

It is the usual practice to provide for *at least* 1 in. movement in 100 ft. of concrete, the additional $\frac{1}{4}$ in. or more being regarded as a factor of safety. This margin of safety is important because concrete does not always behave according to theory. Movement at some joints may be more excessive than at others, sometimes, for no apparent reason, movement will miss a joint and two slabs will move together as one, thus imposing an additional strain on the adjoining expansion joint.

It must also be borne in mind that 100 ft. of concrete *may actually move as much as 1 in.* and joints spaced so as to allow only this amount of movement may close completely. The joint filling material would then be compressed to an extent whereby its structure is broken down and resiliency permanently impaired. *Allowance therefore must be made for the jointing material.* To ensure that it is not overstressed and that a cushion is formed between the slabs, it should not be regularly compressed to much more than 50 per cent of its original thickness.

Slabs 100 ft. long are usually considered impracticable for a number of reasons. One of these is that expansion joints would need to be at least 2 in. wide. Another is that contraction cracks will

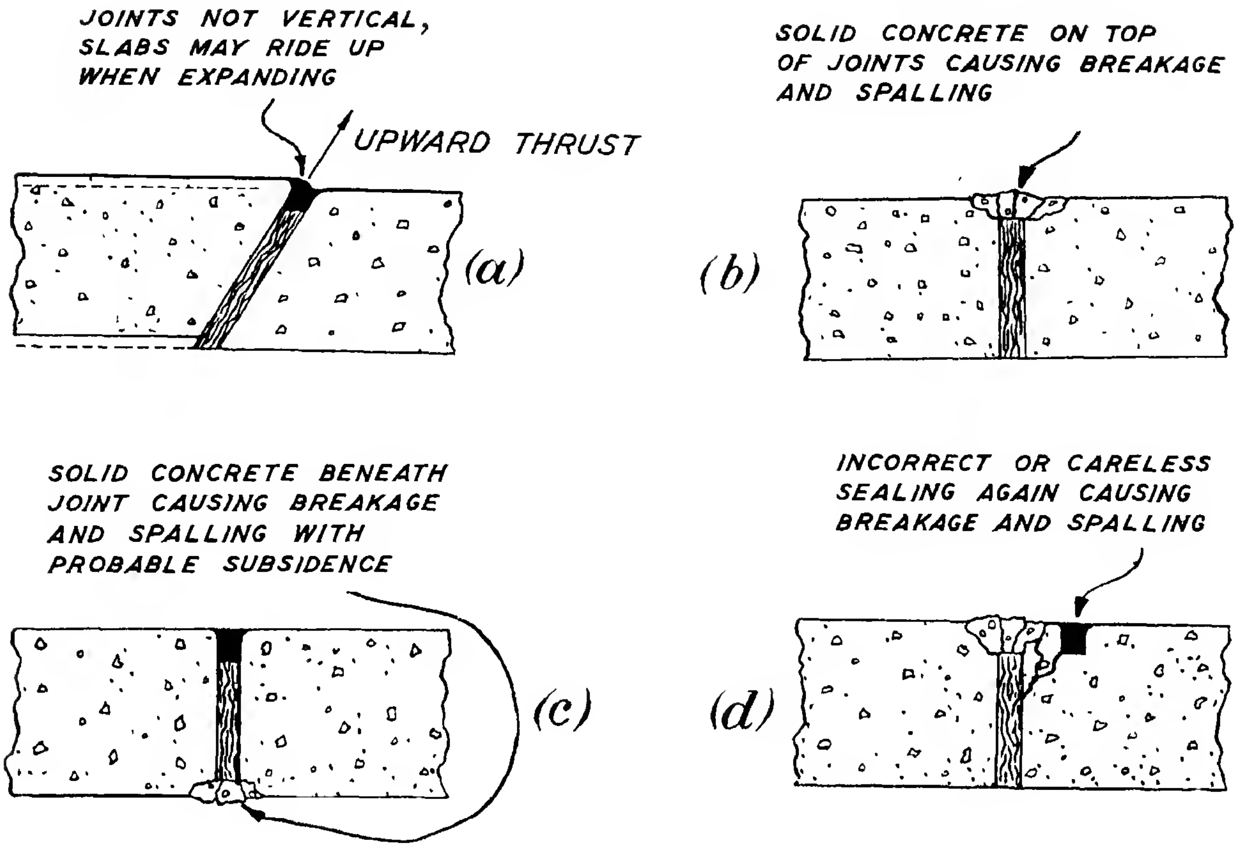


FIG. 1 EXPANSION JOINTING

form due to shrinkage of the concrete on setting causing its failure in tension These cracks would be a constant source of danger from water penetration.

In road construction the usual maximum width of expansion joints is $\frac{1}{2}$ in Joints $\frac{3}{8}$ in wide are frequently used at slightly closer spacing

Assuming the maximum allowance for expansion in 100 ft as—$\frac{7}{8}$ in

To allow for 50 per cent compression of joint filling material $\frac{7}{8} \times 2 = 1\frac{3}{4}$ in

It may therefore be readily seen that a reasonable spacing for $\frac{1}{2}$ in thick joints is 30 ft apart and $\frac{3}{8}$ in thick joints at 25 ft apart.

Expansion joints at this spacing will have the advantage that, under most conditions, they will be close enough to act also as contraction joints and there should be no cracks in the slab from shrinkage of the concrete on setting. Also, in slabs of this length the expansion jointing material will not be regularly compressed to more than half its thickness.

EXPANSION JOINTING MATERIALS

It is not considered sufficient to-day to fill expansion joints with a bituminous mixture, which extrudes and "mushrooms" under pressure, to be broken off and carried away by traffic, and which lacks the power of recovery when contraction takes place

In the U S A, where requirements have necessitated extensive research in concrete road construction, 80 to 90 per cent of highway authorities specify a non-extruding joint filling material. In consideration of cost this is usually of the impregnated fibre type, but others such as cellular or sponge rubber, or cork, are sometimes used.

The joint filling material is, however, frequently regarded as of secondary importance, provided that it is non-extruding, reasonably resilient, rot-proof and durable (Specifications usually call for a minimum of 70 per cent recovery after several cycles of compression to 50 per cent of its original thickness, under a load of not more than 750 lb. per sq. in.)

Primary importance is attached to the compound which seals the top $\frac{3}{4}$ in. or so of the joint This compound has to prevent the entrance of excess water into the joint, also grit and loose stones It must adhere firmly to both slabs and be sufficiently plastic or elastic to maintain a seal under conditions of expansion and contraction It must not flow or run unduly in a hot sun, nor be brittle and friable in temperatures below freezing A variety of compounds are available in the U.S A. and a few here. Further research is being undertaken in this field in England, and new developments are expected in the near future

LOAD TRANSFERENCE AT JOINTS

Again, far more extensive research has been done in the U S A than in England, Westergaard and Frieberg being two of the leading exponents Recent research by Frieberg reveals that. "the effective embedment of a dowel in a concrete slab need not be more than 5 in " He also states that the most effective average spacing is at 12 in. centres

The average length of dowel bars in the U.S.A. is 12 in., and 18 in is rarely exceeded

Research also reveals that if dowels are more than $\frac{1}{8}$ in out of alignment either way, stresses are set up which will lock adjoining slabs, and free movement for expansion and contraction is impossible Dowel bars can be aligned comparatively easily but, unless they are rigidly supported, alignment is soon upset by placing and consolidating the concrete In America, very stringent specifications for the use of ordinary dowels are the result The bars are tightly wired to transverse tie-rods and numbers of stake-pins are used

In consequence manufacturers in the U S A have designed innumerable load-transfer devices, usually incorporating the basic principles of the dowel bar or dowel plate One or two of these devices have definite merit, and the design is such that alignment and fixing is a simple matter Development in this field is now also being undertaken in England, and it is hoped that a simple and effective device may soon be available

ASPHALT ROADS

Prepared in conjunction with the Technical Bureau of the Asphalt Roads Association to whom thanks are due for their assistance and for the illustrations.

THERE is evidence of asphaltic bitumen having been used with considerable skill 3,000 years B.C., in the construction of roads and buildings, etc., but after the fall of Babylon in 538 B.C. the science of using it was lost. It was only about 100 years ago that rock asphalt began again to be employed in the construction of roads.

Rock asphalt is found in various parts of Europe, and is obtained in part in open workings but more generally from mines.

Another type of natural asphalt—lake asphalt—is found in various parts of the world, the most important deposit being in the Island of Trinidad, British West Indies. Though discovered by Sir Walter Raleigh, it was not until the latter part of the last century that it began to be used to any extent for road making purposes.

TYPES OF ASPHALT

The term *Asphalt* covers natural or mechanical mixtures in which asphaltic bitumen is associated with inert mineral matter. It therefore is used not only in respect of the natural asphalts referred to but also in respect of the compounded mixtures containing added aggregate, which are designed specifically for road construction and surfacing, and are prepared in mixing plants.

Rock asphalt is mainly used for the manufacture of compressed and mastic asphalt. Mastic asphalt can also be produced from limestone incorporated with bitumen derived from lake asphalt, or asphaltic bitumen derived from the distillation of selected asphaltic crude oils, those occurring in Mexico and Venezuela being typical.

Rolled asphalt is produced from graded mineral matter incorporated with bitumen derived from lake asphalt, or the asphaltic bitumen referred to above, or a combination of both.

MODERN USES OF ASPHALT

The modern phase of asphalt progress began with the introduction of mixtures of stone and sand with bitumen as a binding agent. The mixtures are generally, used in three different forms of rolled asphalt as follows:

(*a*) *Two-course Asphalt* in which the base course distributes the weight of traffic over the road bed; the wearing course being superimposed.
(*b*) *Single-course Asphalt*
(*c*) *Asphalt carpets*

The success of all asphalt surfacing work depends largely on the selection, grading and proportioning of the aggregate and binder, the object being to produce a durable and completely cohesive material which will permanently retain the whole of the bitumen without excess and possess adequate mechanical strength.

Excess of bitumen was not uncommon with some surfaces laid during the years following the first Great War without due consideration for changes of traffic, and it resulted in some sections becoming slippery under certain conditions. It became customary, in the case of compressed, mastic and rolled asphalt, to provide a roughened surface by covering the asphalt with a layer of $\frac{3}{4}$ or $\frac{1}{2}$ in approved, clean, hard, pre-coated chippings.

Extensive research over about 50 years by the firms specializing in the construction of asphalt roads and by the oil companies has resulted in wide knowledge being obtained of the complex character of the different raw materials.

As a result of collaboration between the British Standards Institution, the Ministry of Transport and the Asphalt Roads Association, British Standard Specifications for asphalt were issued as from 1928 onward. Since 1933 the Department of Scientific and Industrial Research has also undertaken extensive research in connection with asphalt surfaces, and has taken an active part in the revision of the Specifications for compressed, mastic and rolled asphalt issued in 1935 and 1945. The latest British Standards are as follows:

B.S. 348 : 1945—Compressed Natural Rock Asphalt
B.S. 594 : 1945—Rolled Asphalt (Hot Process).
B.S. 596 : 1945—Mastic Asphalt.

Limitations of space prohibit a review in detail of all the considerations underlying the technical aspects of the various forms of asphalt paving mixtures. In deciding which of the three main classes of asphalt paving, i.e. Compressed, Mastic

HOT ROLLED ASPHALT, SHOWING NON-SKID SURFACE TEXTURF

TABLE I—TYPES OF ASPHALT USED FOR VARIOUS PURPOSES

Type of Surface	*City Streets*	*Dock Traffic*	*Main and Trunk Roads*	*Suburban and Secondary Roads*	*Housing Estate Roads*	*Renovation of Existing Surfaces*
Compressed Natural Rock Asphalt (Hot Process)						
Mastic Asphalt						
Rolled Asphalt (Two-course Process)						
Rolled Asphalt (Single-course Process)						
Thin Application Mixtures (Carpet Coats)						

NOTE—*This table should be regarded as no more than a rough and ready guide, and does not imply that the various types of asphalt can only be employed for the purposes shown*

and Rolled Asphalt, is to be used, much will depend on experience and individual preference, but above all full account has to be taken of

(*a*) Volume and nature of traffic
(*b*) Location of Work
(*c*) Climatic Conditions

Bearing the above in mind the following should be regarded as no more than a rough and ready guide, and it should be understood that it does not indicate that the various types of asphalt can *only* be employed for the purposes shown in Table I

NATURAL ROCK ASPHALT

This material consists of bituminous rocks as found in various parts of the world Those generally used come from quarries or mines in the South of France and in Germany, Italy and Switzerland The bitumen content varies as between the different quarries and mines, but is in the region of 10 per cent in the case of the asphalt rock from the countries referred to The differences in texture and other physical characteristics of the rocks cannot be set down as precise technical data, but on an average the mineral aggregate is made up as follows

	%
Silica	1·5
Iron and aluminium oxides	1·0
Calcium Oxide	53·5
Magnesium Oxide	1·0
Carbon Dioxide (present as carbonate)	43·0
	100·0

MASTIC ASPHALT

Mastic Asphalt is manufactured from either natural rock asphalt or limestone in association with an asphaltic cement and coarse aggregate such as stone chippings

These materials are incorporated in such proportions as to give a practically voidless mass of suitable characteristics that can be trowelled to a required form or contour by hand at a temperature in the region of 200°C

Table II gives typical examples of Mastic Asphalt paving mixtures

TABLE II MASTIC ASPHALT PAVING MIXTURES

	1	2*	3	4
Soluble Bitumen	9·0	6·4	10·1	9·5
Rock Asphalt Powder	—	58·6	—	-
Limestone Dust	51·0	—	54·9	50·5
$\frac{3}{8}$ in $\frac{1}{8}$ in Granite	40·0	35·0	35·0	40·0
	100·0	100·0	100·0	100·0
Penetration of Asphaltic Cement at 250°C	20—25	10—25	10—15	25 30

* In connection with this mixture account is taken of the bitumen content of the rock asphalt powder

TABLE III —ROLLED ASPHALT PAVING MIXTURES

	Base Course	*Stone-Filled Wearing Course*	*Single-Course Coarse*	*Single-Course Fine*
Soluble Bitumen	5·5	9·5	6·5	7·5
Filler	—	12·0	7·0	8·5
Sand	24·5	53·5	36·5	44·0
Stone $\frac{3}{8}$ in $1\frac{1}{4}$ in	—	25·0	—	—
Stone $\frac{1}{2}$ in $1\frac{3}{8}$ in	—	—	—	40·0
Stone $1\frac{1}{4}$ in $1\frac{1}{4}$ in	70·0	—	50·0	—
	100·0	100·0	100·0	100·0
Penetration of Asphaltic Cement at 25°C	60—80	45—55	50—60	60—100

ROLLED ASPHALT

Consideration of the factors outlined above will largely determine the type of specification employed, and the physical characteristics of the raw materials will determine the actual proportions of each within the tolerance permissible under B S 594

The permutations and combinations possible within the limits in the Standard Specification permit of a wide range of mixtures The adaptability of the resultant materials prepared from aggregates of various types has made the use of asphalt paving possible on different classes of roads Rolled asphalt has proved successful and has been extensively used on streets in London and large cities and boroughs in the Provinces carrying very heavy traffic, on important country roads including newly-constructed trunk roads with a concrete or hardcore foundation as well as roads with light traffic, e g roads on housing estates

Considering the wide range of combinations the mixtures given in Table II should be regarded only as representative of certain types and in actual practice the composition of the actual mixtures may be subject to variation for the reasons already stated The surface mixtures pre-suppose the application of pre-coated chippings.

As in the case of Mastic asphalt, the asphaltic cement is derived from lake asphalt or asphaltic bitumen or a combination of both.

THIN APPLICATION MIXTURES
(Carpet Coats)

These mixtures cover a wide range of materials varying from the open-textured type of paving based on $\frac{3}{4}$ in chippings to the close-textured finish obtained from mixtures based on quarry fines and/or sand.

A considerable number of individual specifications is possible, and these may be broadly classified as Fine, Medium and Coarse according to the type of aggregate Although thin application mixtures have proved successful there is as yet no Standard Specification Experiments have been made over a number of years, and research is being continued with a view to the establishment of standard mixtures

In the early days of the late war considerable areas of *pervious* asphalt were laid on airfields This material was designed to give a 40 per cent shadow value for camouflage purposes Subsequently a stone-filled impervious asphalt was used for the covering of runways and perimeter tracks and many millions of square yards of this material have been applied

Asphalt has also been used to a large extent in Royal Ordnance Factories, and mention should be made of the special gritless asphalt designed for use in filling sheds A mastic type of asphalt with high stone content was also used as plastic armour protective plating at vital points on ships, with highly satisfactory results

The wartime experience in connection with many different specifications for airfields, roads, buildings and many other types of civil engineering works has made a valuable contribution to our knowledge and further developments in the asphalt field may be expected

COATED MACADAM—BITUMINOUS OR TARRED MACADAM

By A J LYDDON, C B E , M Inst C E , Director of Coated Macadam Industries

It is estimated that over sixty per cent of the mileage of classified roads in Great Britain is surfaced with tarred or bituminous macadam Such widespread use by highway engineers of these materials, which have been given the generic term of "Coated Macadam" by the Federation of Coated Macadam Industries, indicates that this form of surface construction has been found safe, durable and economical With the development of improved bituminous binders and the introduction of efficient laying machines Coated Macadam can provide a durable non-skid surface with excellent smooth-riding qualities

There are many varieties of uses to which the material can be put, for example

1. The provision of single-course or two-course surfacings approximately 3 in thick on newly-constructed stable foundations for highways, airfield runways, housing estate roads and factory roads
2. The strengthening of existing bituminous surfaces to carry heavier traffic loads
3. The reshaping of otherwise sound bituminous crusts to reduce the camber, or to provide super-elevation
4. The application of thin wearing courses to worn or slippery roads
5. The provision of suitable surfacings for footpaths, playgrounds, parade grounds, etc

TYPES OF COATED MACADAM

The principal types of Coated Macadam are·

(*a*) Single Course 2 to 3 in thick

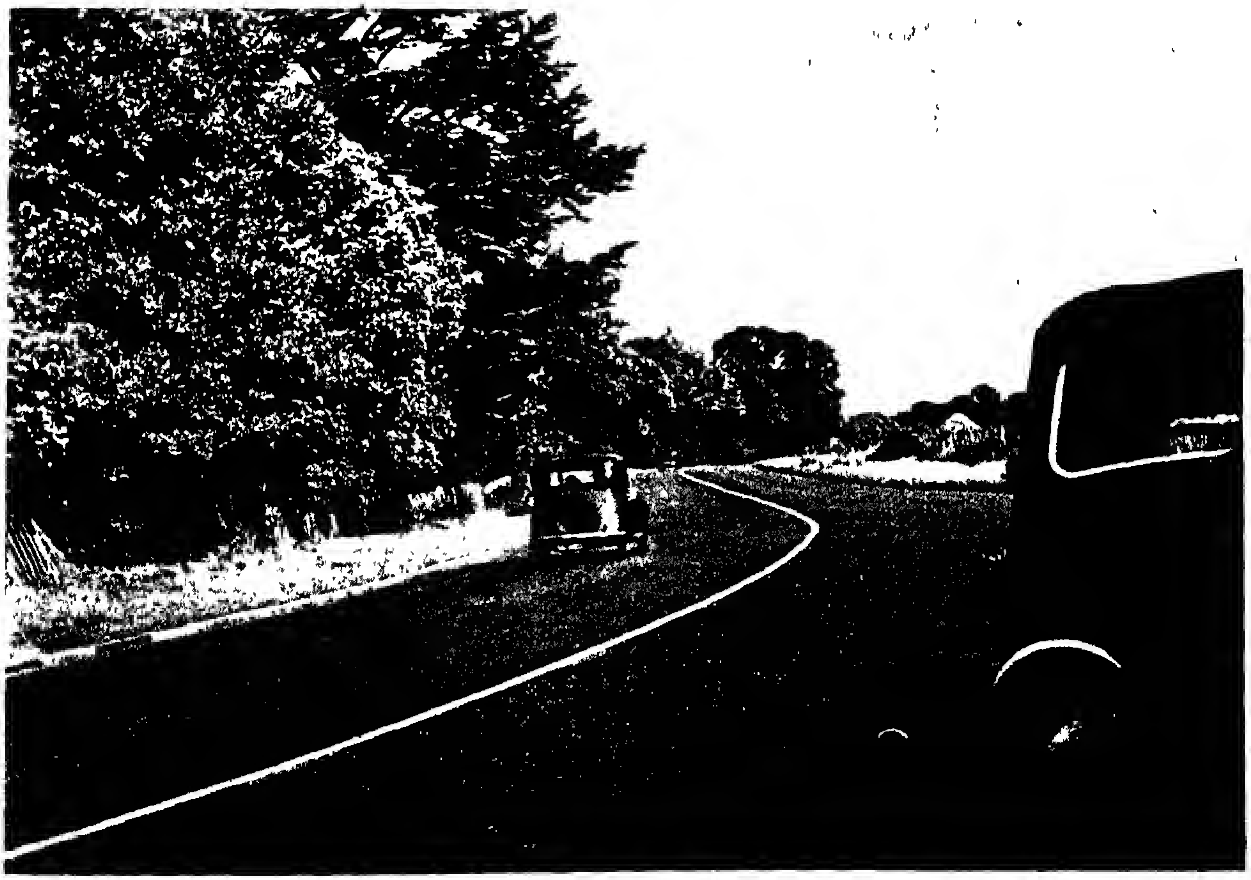


Fig. 1.—Coated Macadam on a Trunk Road

FIG. 2 LAYING COATED MACADAM WEARING COURSE BY FINISHING MACHINE

(*b*) Basecourse	2 to 3 in thick
(*c*) Wearing Course	½ to 1½ in thick
(*d*) Two-course tarmacadam for footpaths, playgrounds, etc.	1½ to 2½ in thick

SINGLE-COURSE MACADAM

For roads carrying a relatively small volume of traffic, such as housing estate, factory or camp roads, the construction frequently consists of a 3-in course of crushed rock or slag coated with tar, bitumen or tar-bitumen compound on a firm base of pitching or hardcore The specification for single-course macadam with either tar or tar-bitumen binder is given in B S 802 · 1945, Table I, and consists of 1½ in. down aggregate which may be laid, either warm or cold, to a thickness of 2 or 3 in., and to increase its durability, pre-coated grit may be rolled into the surface voids Specifications for single-course cold-laid asphalts of varying thicknesses with fluxed asphaltic bitumen or bitumen emulsion as the binder, are given in B S 510 . 1933.

Two-course construction is sometimes favoured for heavily trafficked roads, but good single-course bituminous macadam surfacings have been laid on pitched foundations in various parts of the country where the sub-base favours this class of resurfacing Such construction has given maintenance-free service for over ten years in northern situations

COATED MACADAM BASECOURSE

For many years basecourse material with either tar or bitumen binder and a variety of aggregates has been a common form of Coated Macadam, and it occurs in the surfacing of the majority of our Class I roads The basecourse normally consists of a single layer of coarsely-graded aggregate, either 1½ in down or 2 in down, laid to a consolidated thickness of 2-3 in. In some areas a double layer has frequently been used in the past and is still specified to a decreasing extent, in such cases the bottom layer consists of 2 in down aggregate with the upper layer of 1½ in. down aggregate; the combined thickness is then 4 in. minimum

The basecourse contributes to the strength of the road crust, irons out the irregularities of the

sub-base and provides a correctly shaped surface to which the wearing course will key Generally, the basecourse material must be such that it can be spread at air temperature, but once in position it must be capable of transferring the load from the surface to the base without deformation or movement.

The most widely used basecourse materials are plant-mixed coated macadams made with granite, limestone or slag aggregates and tar or tar-bitumen compounds to the two compositions specified in B S 802. Both compositions have a very coarsely-graded aggregate with little or no fine material and differ essentially only in the maximum size of the aggregate, which is 1½ in for basecourses to be laid 2-2½ in thick, and 2 in for those laid 2½-3 in thick. The tar binder is carefully specified in accordance with B S 76 . 1943, alternative viscosities are specified depending on whether the coated macadam is to be laid in the summer or winter, and whether it is to be spread warm on the day of mixing, or cold after being transported long distances by road or rail, or subsequent to storage for several days The tar is blended so that once the material is spread and rolled in a thin layer a limited loss of volatile oils occurs and the surfacing quickly becomes firm and stable under traffic without becoming brittle.

During the war coated gravel was used to some extent for basecourse work on the lighter trafficked roads in areas in which this was the only available aggregate, and a specification for gravel tarmacadam, B S 1241, was issued in 1945. The material is embodied in a separate specification from the coated macadam made with other aggregates because different requirements have to be met in order to obtain stability under subsequent traffic Coarsely-graded gravel does not lock together under the roller in the same way as a crushed rock or slag, but by the introduction of fine aggregate and the use of a viscous tar binder, a satisfactory gravel basecourse can be obtained The use of a higher viscosity tar makes it desirable that gravel macadam be laid warm on the day of manufacture

Cold-laid bitumen macadam basecourse is specified in B S 511 : 1933, and a new Standard covering both warm-laid and cold-laid bitumen macadam basecourse is in course of preparation

Wearing Courses

A bituminous wearing course is laid as a smooth-riding, non-skid surfacing to either a newly-laid bituminous basecourse or an old road surface in need of reshaping because of deformation, slipperiness or bad riding qualities It is laid to a thickness of from ½-1½ in , depending on the maximum size of aggregate used and the profile of the supporting base and has a life of 5-10 years according to the traffic, climate and general surroundings existing at a particular site Fig 1 shows a typical stretch of coated macadam wearing course on a trunk road.

Fig 3—Coated Macadam on a City Road

Thin bituminous surfacings were first applied about 1930 to sound road crusts as a means of obviating the persistent minor irregularities brought about, or emphasized, by repeated surface dressings on the more heavily trafficked roads In 1934 the Ministry of Transport laid trial lengths of various proprietary materials in different counties and though the war has prevented a final report

being issued, the last available (1939) indicated that many of the surfacings were likely to have a life in excess of five years and possess good resistance to skidding during their life. Considerable experience has since been gained in the preparation of raw materials, mixing technique and methods and speed of laying. The advent of the mechanical laying and finishing machine capable of laying up to half a mile of carriageway daily, with a first-class running surface superior to material laid by hand, provides a further impetus to the use of this class of material. The excellent finish left by the machine is shown in Fig. 2.

The aggregate for the wearing course is usually granite, whinstone, limestone or slag, and in some cases a mixture of granite and limestone, gravel is also used, but to a very limited extent. A special report (No. 3) has recently been issued by the Department of Scientific and Industrial Research "Roadstones: Geological Aspects and Physical Tests." The binder is frequently road tar to B.S. 76 : 1943, but wearing course materials coated with asphaltic bitumen are in extensive use.

Bitumen Carpets.—Consideration is being given to the preparation of a British Standard for bitumen carpets; at present only cold-laid material is covered, in B.S. 511 : 1933. Pending the publication of a British Standard, bitumen carpets may be described under three main types:

(i) *Open textured carpets.*—These are made with a predominance of ¾ and ½ in. aggregate with only 5-20 per cent of fine aggregate and are laid ¾ in. to 1¼ in. thickness.
(ii) *Fine textured carpets*, made with ¼ in. down aggregate, normally laid cold about ½ in. to ¾ in. thickness.
(iii) *Fine textured carpets*, approximately ½ in. thick, on which is superimposed a layer of ¾ in. pre-coated hard chippings.

To determine the most suitable compositions for granite-bitumen and gravel-bitumen compositions of type (i) above, a comprehensive series of trial lengths were laid on a heavily-trafficked road in 1939. The results of this test form the basis of the "Recommendations for Open Textured Asphalt Carpets" given in Wartime Road Note No. 3.

Fine grained carpets are very popular in many counties where a maintenance-free life of ten years is frequently exceeded. They differ chiefly in the type and quantity of the fluxed bitumen binder.

The superimposition of a layer of ¾ in. pre-coated hard chippings is essential to the fine-textured carpet where a rough textured finish to an impervious carpet is desired. An example of this treatment applied to a busy city road is shown in Fig. 3.

Tar Carpets.—Specifications for three types of tar carpet with either granite, limestone or slag aggregate are given in B.S. 802 : 1945, under the description of open, medium and close textured wearing courses.

The open textured type is simple to manufacture as it contains little fine aggregate and also makes use of the same tar (Type A) as the base-course material; it has the further advantage that it can be laid cold. The material should be surface dressed, however, within a year or so of laying in order to seal it against the action of weather and so prevent fraying.

To meet the increasing tendency to avoid dressing a newly-laid surface, a medium-textured tar carpet has been developed. Extensive trials have been made by both the industry and the Department of Scientific and Industrial Research to determine the best proportions of the constituents to provide maximum durability consistent with a satisfactory surface texture, and the compositions in Table 3 of B.S. 802 are based on the results obtained. The mixture contains 15-30 per cent fine aggregate and filler and is coated with Type B or C tar (B.S. 76) which contains less of the lower boiling oils than Type A tar. The materials are mixed in the normal low-temperature tarmacadam plant and laid warm on the day of manufacture.

The close-textured wearing course, in addition to having a higher content of fine aggregate and filler, is made with a much more viscous tar than the medium-textured carpet. For this reason mixing needs to be carried out at a temperature higher than is practical on most tarmacadam plants, and this, coupled with the fact that the material must be laid hot within a few hours of manufacture, will inevitably limit its general adoption.

Tar-coated gravel wearing courses are specified in B.S. 1241 : 1945. Only medium-textured carpets with ½ or ¼ in. maximum size aggregate are specified and these must be laid warm on the day of manufacture. Open-textured gravel-tar wearing courses have not been specified as it has been found essential to include an appreciable quantity of fine aggregate if a reasonable life is to be obtained.

FOOTPATHS AND PLAYGROUNDS

A separate British Standard, B.S. 1242 : 1945, has been prepared to cover the manufacture of

tar-paving for footpaths, playgrounds, parade grounds, etc., with granite, limestone or slag aggregate The normal construction consists of a 1½–2 in. thick base course with 1 in. down aggregate and a ½–⅝ in. thick wearing course with ⅜ in down aggregate.

An alternative form of construction, not yet covered by a British Standard, is to lay the base-course as above but finish with a ½ in. wearing course of cold asphalt

BRITISH STANDARDS FOR COATED MACADAM

The following is a list of relevant British Standards, a number of which are at present under revision:

TARMACADAM AND TAR CARPETS

802	1945	Tarmacadam and Tar Carpets, granite, limestone or slag aggregate
1241	1945	Tarmacadam and Tar Carpets, gravel aggregate
1242	1945	Tarmacadam (Tar-paving) for footpaths, playgrounds, etc.

BINDERS

76	1943	Tar for Road Purposes.

BITUMEN MACADAM

510	1933	Single-coat Asphalt (cold process)
511	1933	Two-coat Asphalt (cold process)

AGGREGATE AND BITUMINOUS MIXTURES

63	1939	Size of Roadstone and Chippings.
598	1940	Sampling and Examination of Bituminous Road Mixtures
812	1943	Sampling and Testing of Mineral Aggregates, Sands and Fillers

ROAD EMULSIONS

Thanks are due to the Ragusa Aphalte Paving Co Ltd., for their assistance in the preparation of this article.

ROAD emulsions of bitumen or tar are chocolate-coloured solutions apparently homogeneous in composition The binding agent of such a solution is a bitumen or refined tar of suitable properties dispersed as minute globules in a water solution containing a small amount of emulsifying agent, usually a soap For the purpose of these notes only bitumen emulsion will be considered

The dispersion of the bitumen into minute globules is effected by passage in a molten condition through a high speed mill in combination with a suitable soap solution This soap solution, termed the emulsifier or stabilizer, functions in facilitating the globular formation of the bitumen in the mill and in providing a suitable soap film or protective colloid around the globules so formed The performance of this protective colloid decides the length of time the emulsion can be stored without coagulation or breakdown, the rate of break of the emulsion or time necessary before the bitumen phase exhibits any binding qualities being indicated initially by a change in colour from chocolate to black, and the wetting properties of the bitumen on the aggregate A weak protective colloid results in immediate or early breakdown of the emulsion, resulting in sludging or coagulation and precipitation of the bitumen from the solution The minute size of the bitumen particles permits the soap protective colloid to resist gravitational stress and prevents distortion of the dispersed bitumen phase particles whilst in suspension in the aqueous phase The diameter of such particles lies mainly between one- and three- thousandths of a millimetre

Stability—This term in general refers to the ability of an emulsion to be stored without detriment to its commercial properties as a road dressing During storage there is some gravitational sedimentation of the dispersed bitumen phase with a "cut" or layer of the aqueous phase at the surface of the emulsion If the sedimentation of such bitumen is moderate, it readily disperses again on rotating the drum or stirring its contents If the sedimentation is heavy, the superimposed weight will cause rupture of the protective colloid with coagulation or clotting of the bitumen particles until, in extreme cases, practically the whole of the bitumen coagulates to a single mass.

It may be assumed that commercial road emulsions will stand up satisfactorily to prolonged storage without detriment It is customarily understood that six months is a reasonable limit for storage

CLASSIFICATION OF EMULSIONS

Emulsions may be classified as follows

(1) Labile, (2) Semi-Stable, (3) Stable

Labile or quick-breaking emulsions are used for road dressing and grouting purposes This is the type mainly dealt with in this article

Semi-Stable emulsions—These are similar to labile emulsions but are more robust in stabilizer, and sometimes incorporate a harder bitumen They are used for coating chippings in a mixer

Stable emulsions have an extremely robust stabilizer and are generally different in character to the types quoted above, and are slow-breaking They are used for fine soil, etc, mixtures for cold asphalt surfacings, and soil stabilization in which they have to stand stresses in admixture with soils and considerable dilution with water

LABILE EMULSIONS (*Bitumen Content and Viscosity*)

The degree of bitumen content and the viscosity of emulsions are important factors in their functioning for the various purposes for which they are applied These factors are governed by B S 434 1935

It is customary to market the emulsions in three grades as follows:

"*A*" *grade* (*heavy*)
Bitumen 62%, Tolerance 2%
Viscosity 12° Engler plus

"*B*" *grade* (*dressing spray grade*)
Bitumen 55%, Tolerance 2%
Viscosity 5°E to 7°E

"*Tack Coat*"
Bitumen 45-50%
Viscosity 3°E

N B—"One degree Engler" represents a rate of flow equal to that of water 5° Engler indicates that the liquor is 5 times as viscous as water, or, that its flow through a given orifice is 1/5th of the velocity of water

Grade "A" emulsion.—This is the heaviest grade made and is used for road dressing, taking chippings up to ½ in (the largest size recommended) The viscosity ranges from 12 to 20°E, the higher viscosities being used for large chippings and roads with a high camber The lower viscosities are sometimes used for grouting on coarsely-graded macadam, applied by hand from a can and broomed

Grade "B" emulsion—This grade is the most commonly used It is used for road dressing with chippings up to ⅜ in mesh It may be applied by brushing or pressure spraying gear manually or mechanically operated It is also used for grouting, pothole patching and as a tack coat under veneer road carpets For the latter purpose a low viscosity emulsion is available containing 45-50 per cent bitumen to give a maximum yardage of thin dressing sufficient for its purpose

These labile emulsions are not normally made to allow dilution with water The effect of addition of water to them is to cause coagulation of an appreciable amount of the bitumen, and the practice should be deprecated

Effect of Weather and Frost on Emulsions in Bulk

The viscosity of an emulsion is normally expressed as its value at a temperature of 20°C (68° Fah) The viscosity decreases with rise in temperature and increases with decrease in temperature

The aqueous phase of the emulsion evaporates on exposure to the air, with coagulation of the bitumen as a skin on the surface of the emulsion For this reason drums should not be left for any length of time with the bungs out

Normal emulsions of the labile type freeze at the same temperature as water and freezing causes precipitation of the bitumen when the aqueous phase thaws out Such emulsions should therefore be protected against frost

Emulsions of the more robust types offer the best resistance to frost, but their slower rate of break makes them unsuitable for road dressing purposes in inclement weather conditions

Emulsions made during the winter season from early November to the end of February are generally treated to render them frost-resisting. Such emulsions have proved satisfactory over a number of years under drastic frost conditions They freeze solid in such conditions but thaw out satisfactorily These emulsions are satisfactory for grouting, pothole patching and general repairs, but are not so satisfactory, in cold and humid winter conditions, for dressing purposes

Functioning of an Emulsion when Spread on a Road

The break or set is initially observed by a change in colour from chocolate to black over the spread film The breaking of an emulsion is aided by warmth, low humidity, wind blowing over the surface, absorption by the surface on which it is spread, the nature of the applied chippings and agitation by the action of rolling in the chippings Retarding conditions are high humidity or damp atmosphere, cold temperature and lack of wind The evaporation, etc, producing the initial break continues, and results in increasing the strength of the remaining stabilizer until the water content of the residue of the emulsion decreases to a point where any further reduction produces coagulation of the bitumen Up to this point the liquid emulsion below the black film is more or less miscible with water, hence the danger of rain washing away newly-applied emulsion Beyond this point, which varies with different emulsions from 12 to 18 per cent water residue, the bitumen deposit is not displaced by rain Obviously, the late phases of breaking proceed more slowly as the process progresses

Supply and Application of the Emulsion

Methods of conveying emulsion to site of works are

1 In steel drums (usually containing about 40 gallons of emulsion) for which the customer is charged if empty drums are not returned to the factory after a reasonable period, and in satisfactory condition
2 Mechanically-operated Pressure Spraying tanks, usually of 1,000 gallons capacity for delivery by road direct from factory to spraying site The emulsion is then sprayed by these machines, the rate of spraying being usually controlled by the speed of the vehicle over the job
3 Alternatively, smaller mechanically-operated pressure sprayers, which may be fed by road tanks or from drums, are used on site
4 Rail tank cars to nearest railway sidings to site of work These cars normally carry 2,000 2,500 gallons They are merely used as mobile storages to feed road tanks
5 Besides the larger sprayers mentioned above, the most handy and popular spraying gear is a manually-operated pressure sprayer dealing with a drum at a time mounted on its chassis For small work watering cans of about 5 gallons capacity are used for application of

the emulsion. The spout of the can is fitted with an external baffle plate to spread the flow of liquid into a broad stream, after leaving the spout.

Application of the Emulsion for Surface Dressing and Grouting

A satisfactory surface dressing job is one where the surface carries a layer of chippings uniformly spread, well packed and well bonded to the road surface by a film of bitumen There should not be any excess of bitumen which would cause bleeding in hot weather Seepage of emulsion into depressions should be avoided or this excess may occur

Rate of application of emulsion and chippings—The yardage obtained by emulsion is dependent on the nature of the surface being treated, weather conditions and the viscosity of emulsion. Obviously an absorbent surface will not permit the same yardage as a close, smooth one, in damp weather an excess of emulsion is harder to break than a reasonable coat, and a high viscosity emulsion cannot be spread as far as a thinner one

Semi-Stable and Stable Emulsions

Semi-Stable emulsions.—These are somewhat similar to the labile type but are generally more robust owing to higher stabilize content They are usually used for coating chippings in a mixer as cold macadam for tennis courts, footpaths, etc. The bitumen used is sometimes harder than for labile emulsions to stiffen up the paving in order to withstand hot weather conditions This type is governed by B S. 510 : 1933 and 511 : 1933.

Stable emulsions.—These are extremely robust chemically and mechanically to stand up to intimate mixing with soils to make cold asphalt paving and for soil stabilization process work They stand up to frosts well and are miscible with water

NATURAL STONE KERB AND SETTS

Prepared in conjunction with the British Granite and Whinstone Federation, to whom thanks are due for their assistance

THERE is as yet no substitute for granite or whinstone kerb which will withstand rough treatment, hard knocks and scrapes, all-weather conditions, including frost, without deterioration after a certain period of time

Drivers of horse-drawn lorries still run their iron-shod wheels against the kerb when going down hill, using it as a brake; drivers of motor vehicles constantly scrape the kerb or run on and off it, and the natural stone stands up well to such usage When a carriageway has to be widened, or some other work done, the natural stone kerb has the great advantage that it does not suffer by being taken up and replaced, and it can be re-dressed, if required The cost of granite and whin is greater, of course, than that of substitute materials, but cost must take into consideration not only the immediate efficiency and appearance, but also the length of life and the likely maintenance costs

Before the war there were substantial imports of granite kerb from Norway and Sweden, where the nature of the rock makes it possible to supply longer lengths than are normally obtainable in Britain Many quarries there immediately adjoin the ports where the stone can be loaded direct onto boats which take coal from England and are able to bring the stone back as ballast at very low rates. There were also imports into England from Mysore, India, and from Northern Ireland and the Channel Isles

Sizes of kerb were standardized in 1931 (B S 435) Normal production in Britain is in lengths varying from 2 ft. 6 in upwards and of the following widths and depths·

12 in. × 8 in flat
12 in × 6 in flat
6 in × 12 in edge
5 in × 10 in edge

For certain local authorities edges are specially bevelled to a depth of 4 in Kerbs are specially bevelled for use on pedestrian crossings (as in Birmingham) so as to make the kerb flush with the road at the point where the pedestrian steps off and on to the pavement or traffic island This type of kerb is illustrated in Fig. 1. Circular kerb can be made to any radius, usually varying from 4 to 30 ft

SETT PAVING

This type of paving is eminently suitable for certain conditions, modern sett paving has the advantages of the sett paving of long ago—notably long life and low maintenance costs—without its disadvantages Criticism of sett paving is usually found to be criticism of old, uneven surfacing familiar in the manufacturing towns of the north

All setts produced today are made in quarries where the quality of the rock is known to be suitable for the purpose Some of the sett roads which were laid perhaps sixty years ago were made from rock of indifferent quality At that time, such foundations as existed were much inferior to the standard of today The best of the old sett roads have served well for anything up to a hundred years

The ordinary *hammer-dressed* or *reeled* sett is dressed to dimensions of breadth and depth from which the variation does not exceed a quarter of an inch, there are no bulges which would prevent close laying and the "arrises" or edges are straight and parallel When laid the width of the gap between the two edges should not exceed three-eighths of an inch *Nidged* setts are specially dressed on the top surface and are very carefully jointed to ensure their fitting close together The dressing of the exposed surface ensures a reasonable non-skid surface, comparable with other modern surfaces

On a foundation of concrete, with correct camber, is laid a carpet or matrix, consisting of sand or a mixture of sand and cement in a dry or semi-dry state. The setts are bedded into this carpet Cement grouting is then poured into the joints This mixes with the cement bedding on which the setts are laid so that when it dries the setts are firmly held The closer the jointing, the more efficient the grouting must be

A modern sett road presents a satisfactory surface for street lighting It has good reflective qualities without causing dazzle Its good appearance is permanent, for the contour of the surface is unaffected by the vagaries of climate, including

FIG. 1.—BEVELLED KERB FOR PEDESTRIAN CROSSINGS

heavy rains and floods, and the rain runs off speedily. The surface is also impervious to oils or other droppings and is ideal for use on bus stops.

Although the initial cost is high, long life and low maintenance costs make sett paving an economical and safe form of road surface.

The size of sett is determined by the traffic to be carried and the particular conditions. In streets with gradients still carrying horse traffic around docks, 3 in. wide by 7 in. deep and 3 in. wide by 6 in. deep granite setts are often used. In other districts, 4 in. wide by 5 in. deep and 4 in. wide by 6 in. deep setts are common, but the 5 × 4 in. sett is an obvious economy, a greater area being covered by the same weight of stone. Other common sizes (width by depth) are: 6 × 4 in. and 6 × 6 in., and smaller ones are supplied to order. Granite and whinstone sett paving is included in B.S. 435 : 1931.

For notes on maintenance of this type of paving see page 400

WOOD PAVING

By LEONARD J VEIT, O B E, F S I

THE consideration of Wood Block Paving as a road surfacing material is a matter of considerable interest Its use extends over more than a hundred years, and it is generally only laid down in the most important thoroughfares of the larger cities and towns, where it carries the maximum amount of traffic of all kinds, failure in any respect would therefore be quickly noticed, and would have serious results on the Industry

It is self-evident that any form of road surface which can successfully carry the volume of traffic daily traversing the great mileage of main roads in London must be of a satisfactory character, and this is further emphasized by the fact that these surfaces have been regularly extended and renewed as required since they were first laid

In the City of London and the 28 Metropolitan Boroughs there are some 300 miles of wood-paved carriageways, carrying heavy and concentrated traffic A further 300 miles, approximately, have been laid in some of the larger provincial towns, so that the subject is of some considerable importance

Seventy per cent of the main roads in the County of London are wood paved, including such well-known thoroughfares as The Strand, Aldwych, Fleet Street, Trafalgar Square, Piccadilly, Regent Street and Whitehall

A reference to London Statistics gives some idea of the volume of traffic carried on wood paving (see Table I)

Further, 12 of the bridges over the River Thames are wood paved, and these carry approximately a quarter of a million vehicles per day of 12 hours

CLASS OF TIMBER

The class of timber to be used for wood paving blocks is a matter of importance, and the accumulated experience gained over a long period is of benefit in selecting the timber Various kinds have been tried from time to time, such as yellow deal, spruce, pitch pine, oak, larch, elm, and beech Considerable areas of American red gum (satin walnut) were also laid down in Westminster about 1900, but this proved very unsatisfactory The hardwoods from Australia—jarrah and karri, were used extensively some thirty to forty years ago, but their use has been generally abandoned for some time past Hardwoods all tend to shrink and "ball" on the surface

The timber which experience has shown to be the most satisfactory is that known as Red or Yellow Deal, and the best qualities are obtained from the ports in the Gulf of Bothnia, Sweden and Finland Excellent qualities have also been obtained from Archangel and the White Sea ports

British Columbian Pine was also used to some extent prior to the outbreak of war in 1939, and so far has proved fairly satisfactory It has also been extensively used internally for end grain flooring in factories, and has proved most satisfactory for this class of work It is very important that the timber should be imported in a properly sawn, graded and seasoned condition

TABLE I

Location	*Number of Vehicles in 12 hours*
Hyde Park Corner	80,536
Trafalgar Square	65,406
Marble Arch	57,698
Edgware Road	44,112
Ludgate Circus	31,864
Brixton Road by Acre Lane	28,809
Blackfriars Bridge	28,267

It is suggested that specifications should require that firms tendering for wood-paving contracts should state the brands and ports of shipment of the timber proposed to be supplied These are nearly all shown in the publication "Shipping Marks on Timber", and will serve as a check on the locality of the supply

Following on the selection of the brands or class of timber, is the cutting and preparation of the blocks for use Careful selection of the deals and sorting of the blocks during cutting is essential if the best results are to be achieved, as deals of the same brand vary in quality in the stacks The object is to obtain blocks of fairly close grain, uniform quality and freedom from the usual defects found in timber, such as shakes, large, loose or dead knots, waney edges and reasonable freedom from

Fig. 1.—Hyde Park Corner
(*Acme Flooring & Paving Co.*)

sapwood—discoloured sapwood being definitely rejected. The blocks should be exactly of the depth specified.

CREOSOTE AND CREOSOTING

The preservation of timber exposed to varying climatic conditions has been recognized for a long time past as a very important feature in its use for constructional purposes. A number of different processes have been in use, but for wood paving blocks, creosoting under pressure is regarded as the best method. For many years, until in fact the great increase in traffic began to make itself felt in different ways on road surfaces, wood blocks were creosoted under what is known as the "full-cell" or "Bethell" process, and an absorption of 10 lb. per cubic foot of timber creosoted was the usual specification requirement.

With the advent of motor traffic and the great increase in volume, weight and speed of vehicles, it was found that this method caused difficulties owing to creosote exuding from the surface and sides of the blocks during hot weather and for some time after they were laid. The "Bethell" process has in consequence, been generally abandoned in favour of the "Rueping" process, under which a rather larger quantity of creosote oil is impregnated in the first instance, and subsequently reduced by a vacuum set up in the cylinders to about 5 lb. per cubic foot. This has proved very satisfactory, and has practically eliminated the difficulties experienced under the older or "full-cell" process.

The British Standards Institution, after consultation with the Authorities concerned, have issued two specifications Nos. 144 : 1936 and 913 . 1940. The former deals fully with Coal Tar Creosote for the Preservation of Timber, and the latter with the Pressure Creosoting of Timber. Type A Coal Tar Creosote and the "Rueping" process are recommended for wood paving blocks.

Supervision and Inspection

Provision should be made in a contract for the supply and laying of wood block paving, for the Engineer to have full power to enter and remain on the Contractor's premises at all reasonable times for the purpose of inspecting and selecting stacks of timber proposed to be used, for superintending the cutting of the blocks and the process of creosoting, particularly to check the quantities of creosote oil absorbed at each charge, and to furnish a detailed report of each operation. It is considered that this provision is a most important factor in the ultimate securing of a satisfactory paving. The usual method of checking the quantity of creosote oil absorbed is to weigh 50 blocks of each charge in the white, after creosoting the same 50 blocks are wiped to remove all moisture from their surfaces. They are then weighed again and the difference between the two weights thus obtained is taken as the weight of creosote oil absorbed.

A wise precaution is to arrange for blocks to be cut and creosoted well ahead of the time they will be required for laying on the road, as this not only ensures that the blocks will be thoroughly dry so far as creosote oil is concerned, but avoids any possibility of delay in proceeding with the work.

FOUNDATIONS

The question of the preparation of the foundations is of vital importance, as, whether for wood paving or any other form of roadway to take large volumes of traffic, well-constructed and adequate foundations are essential. The dislocation of traffic, the inconvenience to the public, and the loss to occupiers of business premises caused by road

operations are so serious that no steps should be neglected to ensure that when making a new road or remaking an old one, the foundations are adequate for all reasonable conditions likely to arise In this connection it is necessary to bear in mind not only the rapid increase in traffic on particular routes, but also the continual advent of new regulations and the introduction of new routes. A road which only takes light or moderate traffic today may in a very short time have its traffic vastly increased Considerable foresight and judgement are therefore necessary to make provision for these contingencies

The use of wood paving is, as a general rule, confined to the central parts of large cities or towns, and except in the case of major improvements and street widenings there is not much difficulty with regard to subsoil In the case of street improvements and widenings, old cellars and basements have frequently to be filled up, often to considerable depths, to carry the new roadway, and the street works have generally to proceed immediately the site is handed over, so that there is very little time for consolidation of filling

In places such as the Strand and Piccadilly, where considerable widenings have taken place, cellars and basements up to 20 ft in depth have had to be filled in, but with the use of suitable hardcore spread in layers not exceeding 12 in in depth, well consolidated by punning, the use of copious supplies of water, careful and continuous supervision, and finally rolling with an 8 to 10 ton roller, no difficulty has been experienced In cases of this kind, single layer reinforcement has been laid over the whole of the filled-in site, extending from four to five ft beyond onto the solid ground Reinforcement is recommended to be used to cover and overlap trenches made by statutory undertakers prior to repaving, and if these are numerous the reinforcement should extend over the whole area of the roadway

In nearly all cases during the past few years (ignoring the war period) and since the great increase in traffic, it has been found necessary and advisable in repaving work to remove the whole of the old concrete foundations and replace with new, 12 in. in thickness, in all Ministry of Transport Class I and II roads, and certain other roads likely to take heavy traffic, and 10 in in thickness for other paved roads Except for exceptional breaking up by statutory undertakers in the future, it is considered that these foundations will last for at least fifty years, and possibly longer To save time, rapid hardening cement should be used For small areas in streets carrying heavy traffic, where minor obstructions may cause serious inconvenience, the use of extra rapid hardening cement is suggested

There are two methods of finishing the surface of concrete for wood paving, which must be very smooth and true—either by bringing up in one body and self-floating, which requires considerable care, but is recommended, or by a separate floating coat, of at least 2 in in thickness, which should be applied immediately the concrete is sufficiently set for the screeds to be formed It is usual to allow about four days to elapse after the completion of the foundations before the blocks are headed up preparatory to being paved

METHODS OF PAVING

Varying with conditions and as dictated by experience, different methods of laying wood blocks have been tried from time to time with a view to ascertaining the most satisfactory under all circumstances As the volume, speed and weight of motor traffic increased considerable difficulty was experienced owing to the courses being shifted on the concrete, and to the admission of water to

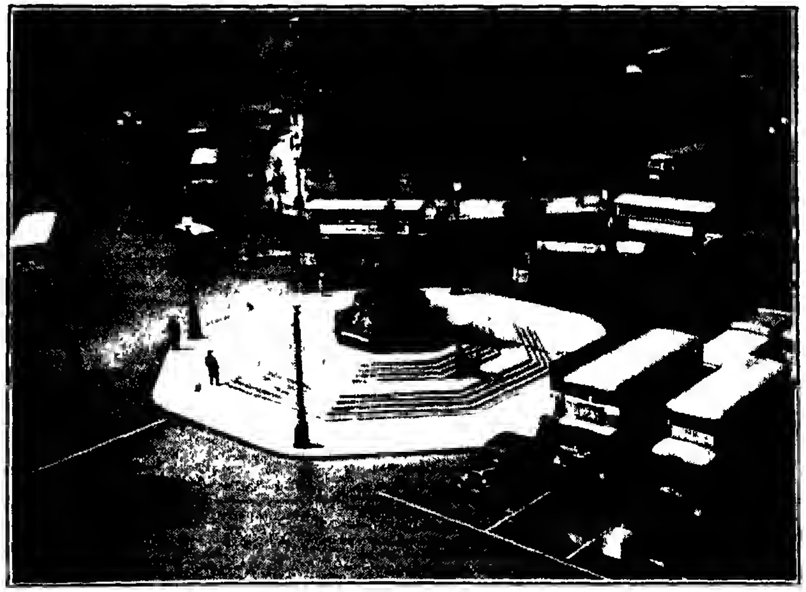


FIG 2 —PICCADILLY CIRCUS
(*Acme Flooring & Paving Co*)

the foundations floating the blocks and causing damage to the surface of the concrete

Several experiments were tried with the object of providing a wood-to-wood connection, thus preventing lateral movement, at the same time allowing for a satisfactory jointing space The best known of these were the "Firmosec" block, and the "Lug" block, both prepared with the same object. Of these the "Firmosec", having proved the most successful, is now adopted in practically all important works, and together with a special bituminous jointing material, provides a very satisfactory water-tight and immovable pavement. In making the "Firmosec" block, the deals are thicknessed by special machinery to a uniform gauge, then cross-cut into blocks, and before being creosoted a spline of wood is fixed along the bottom of one side, two small splines are fixed on the same side, but within about ¾ in. from the top, and a groove or spline is also run along the end of the block (see Fig. 5).

It has been found at times that water from defective joints or a leaking water-pipe under an old area of adjoining paving would penetrate under the new paving, causing trouble, and a satisfactory means of preventing this was the fixing of a stank composed of sheet zinc starting about 1 in below the surface of the new paving at its junction with the old, and extending for the full width of the new paving, and in depth about 2½ in. into the concrete with the lower end turned up to form an anchor, since a vertical sheet of metal was found to rise

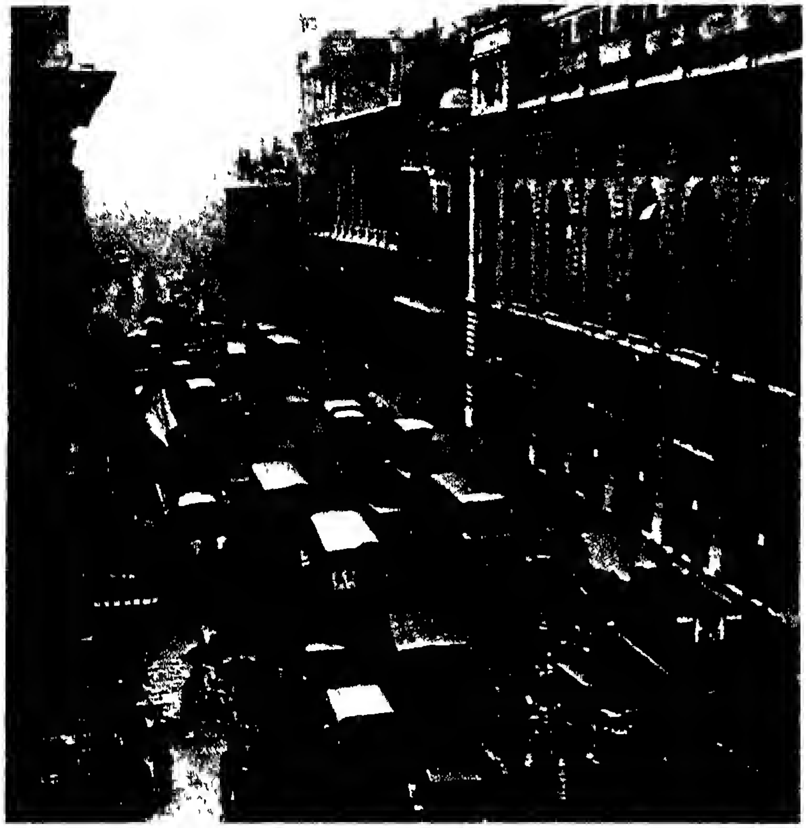


FIG 3.—PICCADILLY, LONDON
(*Improved Wood Paving Co., Ltd*)

FALL AND CROSS SECTIONS

The question of longitudinal fall and cross section has to be given consideration, and where a road is level, a fall of not less than 1 in in 20 ft. for the channels should be provided

With regard to the camber of the road for modern traffic conditions, a chord gradient not exceeding 1 in 48 should be satisfactory, the surface being formed to a parabolic curve The flatter the cross section, providing it is sufficient to carry off the surface water, after allowing for reasonable wear, the better for safety and the more traffic should tend to spread itself over the whole surface of the roadway In cases where there is a considerable difference in the levels of the kerbs on either side of the road, a double kerb should be provided to reduce the fall in the cross section It is usual to provide an expansion joint about 1½ in. wide or space between the first longitudinal course of blocks and the kerbs, a usual method being to fill the lower part with sawdust, sand or clay, and top up with bitumen. Adjacent to bus stopping places, it is a wise precaution to leave no expansion joint, or if this is left, to wedge up the channel courses to prevent the heading joints of the pavement being opened by the traffic.

KERBS

Kerbs should be laid on and backed up with concrete. This forms a good abutment to the haunches of the road, and is a considerable safeguard against any risk with regard to expansion although with good class timber selected

and prepared as previously recommended, there is very little risk of trouble from expansion

ARRANGEMENTS WITH STATUTORY UNDERTAKERS, ETC.

Having taken all necessary steps to ensure the delivery on the site of the specified material, properly prepared, it is necessary to arrange for the satisfactory laying of the new paving. The work can, of course, be carried out either by a contractor or by direct labour, depending upon the policy of the authority concerned It is not considered advisable, where this can possibly be avoided, for the foundation work and the supply and laying of the blocks to be carried out by different parties, as it is very likely to lead to difficulties in the future with regard to maintenance It will be necessary in either case that all essential preliminary steps are taken, i e. apart from the Ministry of Transport requirements, where these apply Adequate notice should be given to all statutory undertakers and transport authorities who may be affected, and to all occupiers of property on the site, giving the extent of the work and the exact date of commencement and completion, which time should not be exceeded except under special and unforeseen circumstances

Careful arrangements should be made with any statutory undertakers who require to execute work As far as possible, this should be started in sufficient time before the date for commencement of the paving operation to avoid the delay and inconvenience which occurs when two or more contractors are trying to operate in the same area It is also a good practice for the Clerk of Works or other official in charge to visit premises having special requirements such as garages, hotels, theatres and other important business houses to make all suitable arrangements for their convenience.

Fig. 4 — Wood Paving in Progress in Bishopsgate, London, E C
(*Improved Wood Paving Co., Ltd*)

ROAD SURFACES AND ACCIDENTS

Having regard to the important question of road accidents, it is considered that some reference should be made to the subject in connection with wood paving.

According to the Ministry of Transport's Return of road accidents in Great Britain for 1938 involving injury, there was a total of 195,664 accidents, and the number of persons killed or injured was 233,357, including 6,648 killed There was a rise in the total of 94,585 since 1926 As a result of continual Press comment and Parliamentary criticism of this serious state of affairs, the House of Lords in 1938 appointed a Select Committee to consider what steps should be taken to reduce the number of casualties on the roads. In December, 1943, a Committee was appointed by the Minister of War Transport to consider the question of road safety, and to review the recommendations of the House of Lords Select Committee An Interim Report was issued in December, 1944

One of the points dealt with in these Reports is the question of road surface and skidding as a cause of accidents. The Committee appointed by the Minister of War Transport appeared to appreciate fully the difficulty of providing and maintaining a non-skid surface under all weather and traffic conditions, stating that there is no known paving material which will retain, throughout its life, its

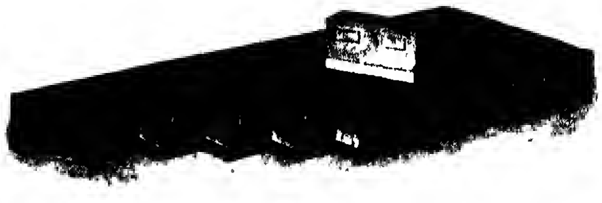


Fig. 5 — The "Firmosec" System of Wood Paving
(*Firmosec Ltd*)

original gripping qualities Important authorities such as the Ministry of War Transport, the Police, The Royal Society for the Prevention of Accidents, the Automobile Association, The Royal Automobile Club, etc., made no criticism of wood paving as a cause of accidents

It is not denied that skidding does take place to a very limited extent in certain positions and under certain weather conditions This is not, however, a normal and regular state of affairs It is also known that skidding occurs on surfaces other than wood. So far, no absolutely skid-proof material has been discovered However efficient a surface may be from this point of view when first laid, under weather and traffic conditions it deteriorates, since the effect of present-day traffic is to smooth and polish the road surface, particularly in certain positions Further, skidding forms only a very small percentage of the numerous causes of road accidents, and the road surface is not the only cause of skidding, bad driving, faulty and badly adjusted brakes, and smoothly-worn tyres have a considerable effect in this respect

In October, 1938, a Questionnaire by the Deputy Chief Engineer of the Ministry of Transport was addressed to the Metropolitan Boroughs, asking, among other things, what complaints of slipperiness on wood paving were received Twenty-six of the twenty-eight Boroughs replied and their replies were to the effect that very few such complaints were received In two of the cases referred to tram tracks were involved, and in another case occasional complaints were received, but were confined to bends and similar places

A careful examination of the Reports published by the Ministry of Transport with regard to road accidents tends to show that wood paving compares very favourably with other road surfaces with regard to skidding With a view to meeting any criticism, the Industry through the Timber Development Association Ltd , and in conjunction with the Ministry of Transport and the Department of Scientific & Industrial Research, have been giving careful attention to this matter and are carrying out experiments with a view to obtaining the safest possible surface Unfortunately, the war has considerably delayed the work of the co-operative body, but in 1940, an interim report was prepared by the Director of the Road Research Department, and this, together with a memorandum compiled by the Timber Development Association Ltd , has been forwarded to the Ministry of Transport

Experiments are now being carried out with a view to ascertaining the most satisfactory and economical mixture of binder and aggregate to form a thin surface carpet for the preservation of badly-worn wood-paved surfaces many of which, owing to war conditions, it has not been possible to replace Research has also been undertaken with a view to finding the most suitable dressing for application to wood-paving surfaces where the possibility of skidding may arise Both tar and bitumen are used as the binding medium, the aggregate being obtained from fine slag dust, crushed granite, and crushed ballast of varying sizes One-coat work and two-coat work are each being tried, but quick results cannot be expected as experimental areas must be down for at least a year for observation of the results under varying climatic conditions With the advantage of more labour and materials these experiments may be further developed

LIFE OF WOOD PAVING

The life of wood pavement is a very important factor, it would appear from careful observation that under modern traffic conditions, providing that the foundations are adequate, and the pavement is laid in accordance with the best recognized practice, an average life of twenty-five to thirty years may be expected The eastern half of Aldwych was the first road laid with the "Firmosec" Block in 1926 and it still has a long life before it Whitehall and Parliament Street were last relaid in 1923 Belgrave Square (Westminster) was laid in 1908 Many other examples could be given of long life

Wood pavement has many advantages for the surfacing of important roads in large cities and towns It is quiet, easily cleansed, economical to maintain, and very durable It is doing its work on highways carrying the greatest intensity of traffic, and its use is based on long practical experience, which is an important consideration with any road surfacing material.

For notes on maintenance of this type of paving, see page 400.

RUBBER PAVING

Prepared in collaboration with the Rubber Growers' Association, to whom thanks are due for their assistance

In the past twenty years much research has been carried out in the application of rubber for street paving. It has long been evident to those who know the properties of rubber that if methods could be found of permanently attaching this resilient material to a solid base, a paving would result with quite distinctive properties. This has been accomplished after some early failures which gradually led up to successful experiments. Sections have been laid and have withstood the test of many years of intensive traffic in London (New Bridge Street, the whole of Lombard Street, and the adjacent George Yard, in Upper Thames Street, in Duke Street, St Marylebone and in Allsop Place, Regent's Park, St Marylebone), Newcastle-on-Tyne, Huddersfield, Birmingham, Oxford and in the Mersey Tunnel, Liverpool. There can be no doubt now in the minds of engineers and surveyors that the problem of applying rubber to street paving is solved and

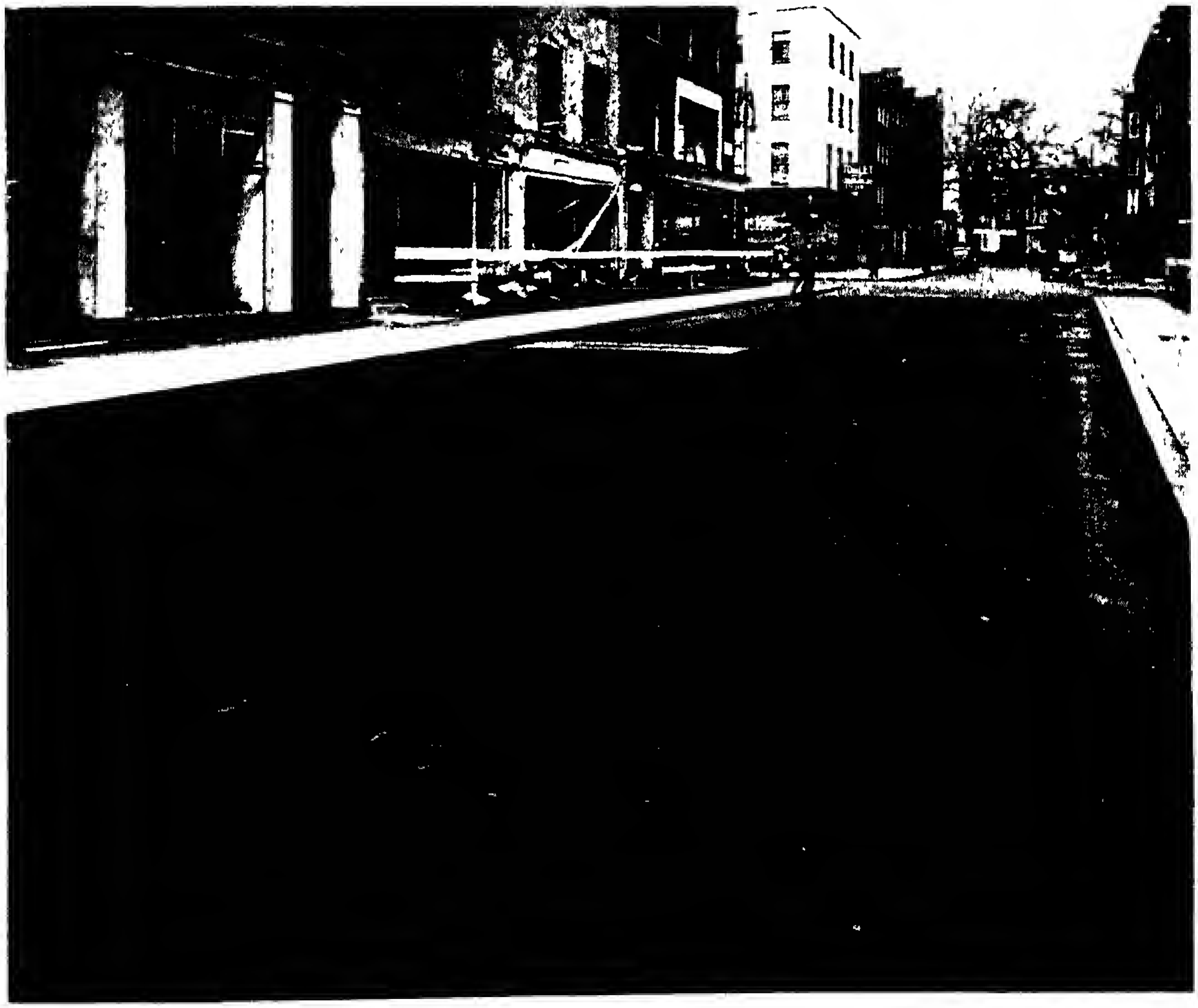


FIG. 1.—"GAISMAN" ANTI-SKID DIAMOND TREAD PAVING BLOCKS LAID IN DUKE STREET, ST MARYLEBONE, LONDON
(Universal Rubber Paviors, Ltd.)

that they can add this product to their list of standard materials for this work.

The most successful rubber paving block so far is the "Gaisman" block, which has been used in all the sections named, and the latest "non-skid" surface example of which has been laid in Duke Street, St Marylebone, in 1940. Fig 1 shows this section of Gaisman non-skid rubber paving, and Fig 2 shows a Gaisman block as laid in that street The rubber cap is permanently attached to the concrete base of the block Fig. 3 shows a block sawn in half to reveal the bond between the rubber and the concrete base of the block

PROPERTIES OF RUBBER PAVING

The surface is as even as parquet flooring and remains perfectly true, no depression waves or pot-holes develop under the stresses and strains of traffic, and therefore no puddles result when wet No dust is formed by virtue of the nature of rubber and as a consequence, no mud The arrises of the "non-skid" pattern remain sharp for many years Rubber is vibration-absorbing and is noiseless By reason of its long life, no repairs or renewals are required for a very long period with consequent advantages to traffic and to the community In fact it forms a surface as smooth and comfortable to the user as rails are to travellers in railway coaches.

The absorption of vibration and the quietness of

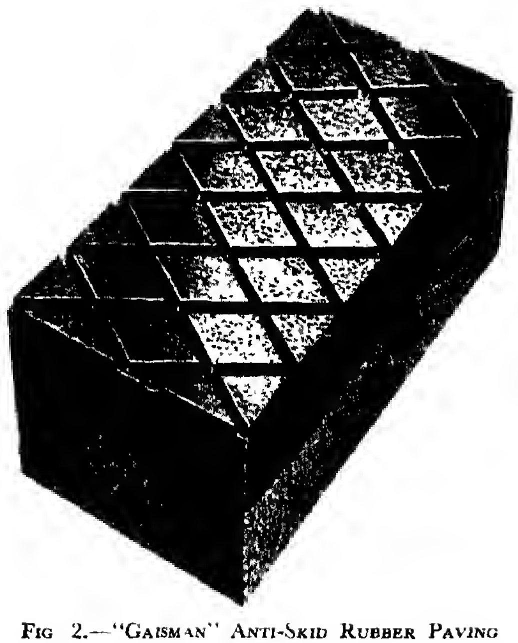


FIG 2.—"GAISMAN" ANTI-SKID RUBBER PAVING BLOCK AS LAID IN DUKE STREET, ST. MARYLEBONE, LONDON
(*Universal Rubber Paviors, Ltd.*)

FIG 3—SECTION OF "GAISMAN" BLOCK SAWN IN TWO ACROSS ITS WIDTH, SHOWING THE BOND BETWEEN THE RUBBER AND THE CONCRETE BASE OF THE BLOCK
(*Universal Rubber Paviors, Ltd*)

a rubber street surface are factors of great importance to the health of the community Much work has been done in America to determine the effect of noise on the well-being of the city worker, and the conclusion arrived at by all observers is that any reduction of noise is desirable and helpful Vibration set up by modern heavy and fast traffic is damaging to buildings, underground services and to the city worker and dweller This vibration is absorbed by the resilience of the rubber surface.

COST OF RUBBER PAVING

By reason of the cost of the raw material and of manufacture, rubber paving is dearer than the well-known forms of street surfacing with the possible exception of ridged granite setts, but when the cost is spread over its life, bearing in mind the durable properties of the material and the consequent absence of repairs, the cost per year of service compares favourably with the other types

LOANS

Rubber paving has been classified for loans by the Ministry of Health, for approved schemes to be carried out with approved blocks and methods, and this should prove a milestone in the development and advance of this type of road surfacing.

Since Pearl Harbour and the entry of the Japanese into the war, resulting in the overrunning of the Malay States, Indo China and the Dutch East Indies, with consequent cutting-off of most of the supply of natural rubber to the Allies, restrictions have been imposed by the Governments concerned on the use of rubber for many

purposes, including rubber paving, but the position will now gradually improve and it may be assumed that natural rubber will soon again be available for this manufacture During the period of short supply of natural rubber the Americans by an amazing industrial accomplishment have produced synthetic substitutes of rubber in very large quantities which enabled the war needs of the Allies to be met, but these synthetics have not yet been tried in rubber paving As no laboratory tests can adequately replace actual road tests, it has taken long years of wear on roads carrying heavy traffic, conclusively to establish the merits of road blocks surfaced with a natural rubber compound It remains yet to be proved how similar blocks made from the best of these synthetics will behave

Before the outbreak of the Second World War the annual consumption of natural rubber was of the order of 1,000,000 tons The potential production of natural rubber from present planted areas when normal conditions are restored is estimated at over 1,500,000 tons per annum The Americans estimate their capacity for producing synthetic rubber substitutes at over 1,000,000 tons per annum, to which must be added the capacity of Russia and Germany It is too early to evaluate the competitive merits of natural rubber and synthetic substitutes, especially in the motor industry which absorbed about two-thirds of all the rubber used before the war, but, even allowing for the rapid expansion of existing uses, new outlets will be very desirable Once the Far East has settled down there should be no difficulty in meeting all requirements which are likely to result from the adoption of rubber paving in city and town centres, where its special properties make it particularly attractive.

MANUFACTURERS' SCHEDULES

GENERAL MATERIALS

PRODUCTS (INCLUDING TRADE NAME IF ANY)	BRIEF DESCRIPTION	STANDARD TYPES AND/OR SIZES	GENERAL USES AND APPLICATIONS	SPECIAL USES AND ADVANTAGES	IMPORTANT INFORMATION CONCERNING PRODUCTS
ABERTHAW & BRISTOL CHANNEL PORTLAND CEMENT CO, LTD, CARDIFF					
ABERTHAW PORTLAND CEMENT "DRUID" and "MITRE" BRANDS	To B S S	Supplied in 1 cwt paper bags	General concrete work	Reliability	Uniformity of chemical composition and physical properties
"ABERCRETE" RAPID HARDENING PORTLAND CEMENT	To B S S	Ditto	For constructions requiring high early strength	Greater speed in construction and early release of shuttering	As above
"ABERTHAW" LOW HEAT PORTLAND CEMENT	To B S S	Ditto	For mass concrete construction	Reduction in shrinkage cracking of concrete	A true "low heat" cement obtained by suitable adjustments in chemical composition and high fineness of grinding
"ABERTONE"	Coloured Portland Cement (rapid-hardening)	Ditto	For coloured surfaces and renderings	—	—
THE ACME FLOORING & PAVING CO (1904), LTD, BARKING, ESSEX					
WOOD PAVING "FIRMOSEC" SYSTEM DOWELLED SYSTEM BITUMEN EMULSION FOR SURFACE DRESSING	Creosoted softwood Deal British Columbian Pine	4, 4½ and 5 in deep 8 and 9 in long 3 in wide Creosoted under pressure	Surfacing of highways, particularly heavy traffic, city and town streets and bridges.	For bascule type bridge The dowelled system provides for blocks to be dowelled to each other The paving is secured to the subdecking by coach screws	Carefully selected timber creosoted by latest improved methods Long-term free maintenance and subsequent low maintenance costs
THE ALSTON LIMESTONE CO, LTD, NEWCASTLE-ON-TYNE					
WHINSTONE CHIPPINGS and ROADSTONE TARRED WHINSTONE	—	All sizes from 1 in down to dust All sizes from 10 in down to 1½ in All sizes from 2½ in down to ⅛ in	Concrete aggregate, road-making	A concrete aggregate of first-class quality	As used by County and Municipal Authorities and well-known Public Works and Road making Contractors
AMALGAMATED ROADSTONE CORPORATION, LTD, LONDON, S W 1					
GRANITE, BASALT, WHINSTONE AND LIMESTONE	—	All standard sizes to B S S supplied dry or coated	Aggregate for concrete, tar-macadam and asphalt Chippings for tar-spraying, granolithic work, etc Hardcore, etc, for foundations Fillers for asphalt and other bituminous compounds	—	
ASPHALTE CARPETS, LTD, LONDON, S W 10					
"ASCAMAT" COLD ASPHALT (FINE)	Manufactured from slag or granite aggregate coated with fluxed bitumen	Graded ⅛ in to dust	Surfacing of carriageways, footpaths etc Trench re-instatements Can be laid to thicknesses varying from 1¼–⅜ in	Laid cold Stored indefinitely Non-skid Can be laid to levels or feathered out	—
(COARSE)	Ditto	Graded ⅜ in to dust	Surfacing of carriageways and footpaths	Laid cold Non-skid	-
"ASCAMULS" COLD EMULSION	55% and 62% bitumen content	—	Surfacing, dressing or grouting	—	—
(TACK COAT)	30% bitumen content	—	For use as tack coat under carpet coats	—	—
ASSOCIATED ASPHALT CO., LTD., LONDON, S W 7					
ROLLED ASPHALT	Road Surfacing material.	British Standard Specification	Surfacing of roads, footways, etc	—	—
"RUFFIT" CARPETING	Bituminous granite carpeting	⅜, ½ in graded aggregate	Carpeting of carriageways	—	—
MASTIC ASPHALT	Road surfacing material.	British Standard Specification	Surfacing of roads, footways, etc.	—	—
MASTIC ASPHALT	Asphalt for constructional work	British Standard Specification.	Waterproof covering of roofs, floors and tanking	—	A selection of coloured mastics are available for surfacing of floors

PRODUCTS (INCLUDING TRADE NAME IF ANY)	BRIEF DESCRIPTION	STANDARD TYPES AND/OR SIZES	GENERAL USES AND APPLICATIONS	SPECIAL USES AND ADVANTAGES	IMPORTANT INFORMATION CONCERNING PRODUCTS
BERRY WIGGINS & CO., LTD., LONDON, W.C.2					
"Coldcoat"	Cold bitumen emulsion for roads, paths and drives		For surface dressing, grouting, semi grouting and tack coats	Road repairs can be undertaken and continued in any but the most inclement weather conditions	—
BETTY AND TOM, LIMITED, LONDON, S.W.1					
Broken Stone Tarmacadam		All sizes to B.S.S.	Concrete aggregate, etc. Road surfacing	—	Stone breaks cubically
W. SINGLETON BIRCH & SONS, LTD., BARNETBY, LINCS					
Pitching Stone	Limestone	As quarried and dug by mechanical shovel (excavator)	Road foundation and widening	Cheap, hard and satisfactory	Widely used in the neighbourhood for road foundations
Overburden	Surface soil and small top stone	As excavator dug, loaded all small stuff	Filling	Consolidates well and makes a good surface when worked	Extensively used for filling of swamps, etc.
BITULAC, LTD., NEWCASTLE-ON-TYNE					
"Bitulac" Verge Composition	Grass-green colour for macadam verges		—	—	—
BREEDON & CLOUD HILL LIME WORKS, LTD., DERBY					
Breedon Gravel	Crushed magnesium limestone or dolomite	Red and golden amber ⅜ in. down to fines	Footpaths top dressing, carriage drives	Will set and provide a dustless wearing surface without the addition of a binder	1 ton will cover 20 sq. yd. about 1½ in. thick
Tarred Lime stone	—	All sizes	—	—	—
Breedon Self Setting Footpath Gravel	Crushed magnesium limestone or dolomite	Red and golden amber ⅜ in. down to fines	For surfacing or top dressing footpaths, drives and road verges	Will set and provide a dustless wearing surface without the addition of a binder	1 ton will cover 20 sq. yd. laid approx. 1½ in. thick
Tarred Lime stone	—	All sizes	—	—	—
Clean Limestone Chippings	-	All sizes	—	—	—
WILLIAM BRIGGS & SONS, LTD., DUNDEE					
"Briggsfalt" Carpet	Very durable road surfacing	—	—	All roads	Laid by own men
"Bituphalt"	Road compound for spraying and coating	In 40 gall. drums	—	—	—
"Colmulsion"	Cold emulsion for spraying	In 40 gall. drums	—	—	—
"Filleroid"	Bituminous matrix	Supplied in powder form	Lengthens the life of carpet coating	—	Easily laid
"Challenge" Expansion Jointing	For concrete roads	¼, ⅜, ½ and ¾ in. thicknesses	—	—	-
All types of asphalt roads according to B.S. Specifications	—	--	—		--
THE BRISTOL STONE & CONCRETE CO., LTD., Near BATH					
"Bickrete" Kerbs, Fence Posts, Paving Slabs	Cast concrete products	--	—	-	—
BRISTOWES TARVIA, LTD., LONDON, S.W.7					
"Tarvia"	Reinforced proprietary tar compound	Grade "A" for mixing and grouting Grade "B" for surface dressing Grade "K.P." for cold patching	A standardized product of consistent and dependable quality, not having the variations which are permissible by the wide limits of the B.S.S.	Grade K.P. For patching pot-holes and levelling depressions A unique product for mixing small batches of any stone Used cold—contains no water	"Tarvia" registered as trade mark in 1906
BRITISH BITUMEN EMULSIONS, LTD., SLOUGH, BUCKS					
"Colfix"	Quick breaking, cold bitumen emulsion, 3 grades 30% tack coat 55% } grouting 62% } and surfacing	40/45 gallon returnable drums or barrels, or in bulk	Road surface dressing, grouting and mixing	Applied cold throughout most of the year	-

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BRITISH BITUMEN EMULSIONS, LTD, SLOUGH, BUCKS—*continued*					
"Lomix"	Stable bitumen emulsion	Ditto	Mixing with soil and aggregate for soil stabilization	—	—
"Lomix" 'R'	Stable mixing emulsion, for mixing with aggregate for retread and mixing "in situ"	Ditto	The stability of this emulsion is midway between our quick breaking emulsions and "Lomix" stable emulsion When mixed "in situ" with aggregate, traffic can use the road almost immediately	—	—
BRITISH TAR PRODUCTS, LTD, SHEFFIELD, 10					
Refined Tar	Usual B S Specification	—	Spraying and grouting	—	—
BROOKES', LTD, HALIFAX					
"Nonslip" (regd) Flags	Hard York stone	ft in ft in in 3 0 × 2 × 2½ or 2 2 6 × 2 × 2½ or 2 2 0 × 2 × 2½ or 2	For street footpaths, etc	Safe foothold, great durability and pleasing appearance	—
"Nonslip" (regd) Landings, Steps and Architectural Dressings	—	Ditto	Ditto	—	—
"Perfecta" and Adamant" Flags	Hydraulic pressed	Ditto	Ditto		
"Hexacrete"	Concrete roadway paving blocks	12 in diameter hexagonal shape	—		
Kerbs, Setts Macadam and Chippings	Brooks' granite	—	—	-	
Flags, Kerbs, Setts	Brooks' hard York stone	—			-
"Silex" (regd) Brand Flags, Steps, Landings					
"Koluol"	Bitumen emulsion for cold application	-	Grouting, surface dressing	Can be applied cold	—
"Settasitc"	Bituminous asphaltic filled grout	—	Grouting, surfacing joint sealing surfacing sett paving, etc	—	—
"Tardurabit"	Tar bitumen compound	—	Grouting, surface dressing, mixing macadam	—	—
Safety Anti-Frost Extract		—	For thawing frost, snow and ice and counteracting freezing	—	-
"Vanol"	Hand cleaner	—	Removes tar bitumen, oil and grease, etc	—	—
GEORGE M CALLENDER & CO, LTD, LONDON, S W 1					
"Rezilia" Fibrous bituminous expansion joint for concrete roads	A compound of pure bitumen and selected fibrous material formed into sheets with outer covers of bitumen felt	Manufactured in thicknesses of ¼, ⅜, ½, ⅝, ¾ and 1 in Supplied in boards 6 ft long and in varying widths to suit thickness of road	For concrete roads, and similar constructions, where an elastic, stable, waterproof and durable expansion joint is required	"Rezilia" supersedes the customary expansion joint formation of filling a cavity with hot liquid pitch or bitumen It is used in a cold condition and prevents interruption in the continuous progress of the concrete work It possesses the required degree of elasticity to absorb and accommodate movements in the concrete caused by expansion and contraction and will not flow out of position	
CARPAVE, LTD, LONDON, S W 1					
"Carpave"	Cold asphalt, patent road surfacing material	—	Mixed hot—laid cold	"Carpave" presents no difficulties in laying, road can be opened to traffic immediately after rolling	A "Carpave" surface is entirely non skid
CARREGY-LLAM QUARRIES, LTD, LONDON, S W 1					
Broken Stone	Granite porphyry	All sizes to B S S	Aggregate for concrete, asphalt, tarmacadam Chippings for tar-spraying and granolithic work	—	Stone has exceptionally favourable covering capacity (Specific gravity 2 63)

PRODUCTS (INCLUDING TRADE NAME IF ANY)	BRIEF DESCRIPTION	STANDARD TYPES AND/OR SIZES	GENERAL USES AND APPLICATIONS	SPECIAL USES AND ADVANTAGES	IMPORTANT INFORMATION CONCERNING PRODUCTS
CARRICK, HOWAT & LINDSAY, PAISLEY					
LINDSAY'S PATENT SURFACE FABRIC	Steel grille surface reinforcement for concrete and asphalt paving	1 by 12 in gauge steel strips spaced 1 in apart	To withstand effects of heavy concentrated loads, wheel traffic and the dumping of heavy materials on concrete and asphalt	May be laid only in those portions of the paving where the traffic is most severe	Conforms to cambers, and cannot warp
"FABROSEAL"	Solution	Supplied in 5 and 10 gallon drums	To dustproof, oilproof, waterproof, case harden and rapid harden concrete	For mass concrete, rendering, bonding, damp-proofing, anti freezing, etc	-
THE CEMENT MARKETING CO., LTD., LONDON, S.W.1					
BLUE CIRCLE	Normal Portland cement	To B.S. 12: 1940	General concrete work		
"417 CEMENT"	Concrete made with '417 Cement' has a high early strength and is quick setting		Concrete road foundations and concrete roads	Can be surfaced and carry traffic within 24 hours	No admixtures should be used
"LIGHTNING" BRAND HIGH-ALUMINA CEMENT	Ultra rapid hardening properties	To B.S. 915: 1940. 1 cwt bags	Concrete road foundations and concrete roads. Tram track repairs	Can be surfaced and carry traffic within 24 hours. Less liable to damage by frost	Should be mixed with ordinary Portland cement
"FERROCRETE"	Rapid-hardening cement which has a normal setting time		Concrete roads	Roads can be opened to traffic in 4-7 days	
"COLORCRETE"	Rapid hardening coloured Portland cement	Red, buff, khaki and dark. 1 cwt paper bags	Roads, paving, verges, cycle tracks, pedestrian crossings, car parks, etc		-
CHEECOL PROCESSES, LIMITED, LONDON, S.W.1					
"CHEECOL"	Cement grouting agent		Mixing concrete *in situ*	High strength concrete by pouring	
THE CLIFFE HILL GRANITE CO., LTD., MARKFIELD, LEICESTER					
CRUSHED GRANITE, TARMACADAM, BITUMINISED GRANITE, KERB SETTS, CONCRETE PAVING, CONCRETE KERB		In all standard sizes and gradings	Roadmaking, concrete aggregates, paving	High grade non-slip durable surfaces	Leicestershire syenite of very high quality
COLAS PRODUCTS, LTD., BISHOPSGATE, LONDON, E.C.3					
"COLAS"	Pure bitumen emulsion		For surface dressing and grouting, reconditioning of roads		Manufactured in two grades 55 and 62% bitumen content
"COLASMIX A" AND COLASMIX B	Semi-stable emulsions for premix construction	-	Used for the production of cold asphalt and cold bituminous macadam respectively	Can be manufactured on site in any standard concrete mixer	With 'Colasmix B' a seal coat of Colas should be applied
"COLASCURE"	Concrete curing emulsion		Apply at 8-10 sq yds per gallon, and blind with sand at 400 sq yds per ton		Apply as soon as concrete is hard enough to be trodden on without leaving any impression
"TERCOLAS"	A stable emulsion for mixing with fine and low grade aggregates	-	For low cost surfacing of road and footpaths	Mixing may be carried out *in situ* or in a concrete mixer	A seal coat of Colas should be applied
"COLASTAK"	Special emulsion of low viscosity and moderate stability		Used as a tack coat for bonding bituminous carpets to their base	-	Apply at 8-10 sq yds per gallon and lightly blind with carpeting material
COLAS FINE ASPHALT "COLASFALT"	Fine graded cold laid Asphalts	-	For carpeting all types of road surfaces		Can be laid to any thickness from ½ to 1 in
"ASPHALTIC" Grades, A, B, & C	A hot bitumen compound of "cut-back" type	-	For surface dressing, macadam mixing, grouting and coarse graded carpet mixing	-	Toxic or non toxic grades available
COLBIT, LTD., MANCHESTER					
"COLBIT"	Emulsified bitumen made in accordance with B.S. 434	Grade 60 containing 62% bitumen, grade 50 containing 55% bitumen	Making of roads, paths, etc	Also used for waterproofing concrete, etc	Supplies always available. Fullest technical assistance on all subjects

PRODUCTS (INCLUDING TRADE NAME IF ANY)	BRIEF DESCRIPTION	STANDARD TYPES AND/OR SIZES	GENERAL USES AND APPLICATIONS	SPECIAL USES AND ADVANTAGES	IMPORTANT INFORMATION CONCERNING PRODUCTS
COLBIT, LTD, MANCHESTER—*continued*					
"Colgrip"	Filled bitumen	Mixture of 65% bitumen and finely ground limestone or slate dust	Surface dressing tarmacadam roads, sett roads laying setts, waterproofing concrete work	This material is a very inert waterproof material which is easy to lay	To be applied at a temperature of 220 240° F
"Sprabit"	Fluxed bitumen	85 95% bitumen	Road surfacing	–	—
Limestone Flour	Finely divided calcium carbonate	99% passing a 200 mesh	As a filler for road materials	As a filler for the rubber trade	
THE CONCRETE UNIT COMPANY LTD, MANCHESTER, 17					
"Stonehenge"	Hydraulically pressed non slip paving flags and fencing-posts	–	—	—	—
CONSTABLES (MATLOCK QUARRIES), LTD, MATLOCK					
Lump Limestone	Hard Derbyshire mountain limestone (carboniferous) with high crushing strength	6–9 in and 9–12 in	Road foundations	—	—
Crushed Limestone	Ditto	All sizes to B S S	Concrete aggregates chippings for tar spraying and aggregate for rolled asphalt and mastic asphalt for roadways	—	—
Tarred and Bituminous Limestone	Ditto	All sizes to B S S	Roads, footpaths, drives school playgrounds, etc	—	—
CORNISH ROAD METAL, LTD, LONDON, S W 1					
Broken Stone	—	To B S S	Roads, civil engineering, etc	—	—
CROWLEY, RUSSELL & CO, LTD, GLASGOW, C 2					
"C R" Binder	Liquid bitumen for mixing carpet coats etc		Road surfacing materials	In addition to normal methods of delivery in drums or barrels, this company has a fleet of insulated road and rail cars Road tank capacity 800–1600 gallons Rail tank capacity 2000–3000 gallons	Manufacturing centres for liquid bitumen and asphaltic emulsions—Glasgow and Castleford, Yorks A fleet of portable asphalt plants is available for work in Scotland and the North of England
"C R" Spray	Liquid bitumen for surface spraying	To B S S			
"C R" Emulsion	Asphaltic emulsion for spraying, grouting, patching, etc				
CULLACORTS, LTD, POOLE					
Grasstone Coloured Chippings	Granite or Limestone	$\frac{3}{16}$, $\frac{1}{4}$, $\frac{1}{2}$, $\frac{3}{4}$ in	Drives, pathways, etc May be sprinkled or in layers of $\frac{1}{4}$ to $\frac{1}{2}$-in thickness	Permanent colour	Always fresh-looking—no attention or upkeep
Coloured Cement	—	Colours red, brown pink, black, blue Packed in 1 cwt bags	Used as ordinary cement for concrete car parks, drives, paths, etc	Permanent colour	Production pending
DAMASFALT MANUFACTURING COMPANY, LTD, LONDON, S W 1					
Asphalt for Surfacing Roads and Footpaths	Special fine asphalt which gives a "sandpaper" non skid surface	—		Can be laid by unskilled labour	Eminently suitable where only a thin regulating surface is required
C. DAVIDSON & SONS, LTD, MUGIE MOSS, ABERDEEN					
"Ibeco" Waterproof Kraft Paper	A tough and reliable waterproof	Five thicknesses in rolls 36 × 72 in wide and 100 and 250 yards long	For concrete underlays and curing overlays For sarking and insulating work	Clean and easy to handle Very tough and pliable Unaffected by extremes of climate Prevents unwanted drainage from the mix during setting and hardening	Waterproofed by incorporation of patented bitumen emulsion into the paper fibres while these are still in fluid state The paper is thereby waterproofed throughout its texture, bitumen cannot harden or crack to cause breakage,
DERBYSHIRE STONE, LTD., MATLOCK					
See Greatorex & Sons, Ltd, Hardamac, Ltd, Constables (Matlock Quarries), Ltd, Geo Lovegrove & Co, Ltd					
DEVON CONCRETE WORKS, LTD., BARNSTAPLE					
"Devon" Paving Slabs	Cast stone and concrete In granite, "Bideford" grit, limestone or flint shingle concrete	3 ft 0 in × 2 ft 2 ft 6 in × 2 ft 2 ft 0 in × 2 ft 1 ft 6 in × 2 ft × 2½ or 2 in thick	—	Can be supplied with carborundum non-slip face	—

PRODUCTS (INCLUDING TRADE NAME IF ANY)	BRIEF DESCRIPTION	STANDARD TYPES AND/OR SIZES	GENERAL USES AND APPLICATIONS	SPECIAL USES AND ADVANTAGES	IMPORTANT INFORMATION CONCERNING PRODUCTS
DORMAN, LONG & CO, LTD, MIDDLESBROUGH					
"B V" Concrete Flags	*Special Slag Aggregate*	3×2 ft, 2½ × 2 ft, 2 ft × 2 ft, 2½ in and 2 in thickness	Paving footpaths, etc	•	
"B V" Concrete Kerbs	Ditto	10 ft × 8 in and 6 × 12 in in 3 ft 5 in – 10 in lengths	Roads and footpaths		
"B V" Concrete Slag	*Our Special Product*	⅜ in to fine	For concreting	—	
Wire Rods	In straight lengths	Up to 30 ft long, 7/16–⅝ in dia	Reinforcement of concrete		—
Reinforcing Bars	Ditto	¼–2½ in dia	Ditto	—	—
NORMAN W DUNN & CO, LTD, DUNNINGTON, YORK					
"Penrhyn's Grout"	75% slate flour 25% bitumen	Supplied in solid block form	Melted to liquid form and squeegeed on to the road surface, chippings then spread and rolled in	As a sealing coat on tarred macadam. For blotting out abandoned tram tracks and old sett paving	Manufactured at our static plants, and can be made on site with mobile mixing units
"Masterphalt"	Clean, carefully graded granite, whinstone or dense slag, coated with bitumen binder and slate flour	Various grades from ¾ in down	Coated stone for road surfacing	Rapidity in laying. Does not bleed or crack in heat or cold. Does not require manual dressing. Is non slippery	Is open to traffic immediately after rolling
"Duncophalt"	Carefully graded, hard washed, crushed gravel, coated with bitumen binder	Various grades from 2¼ in down	—	Is suitable for both trunk and district roads	—
"Fullersite"	Inert slate flour		As a filler	Contains a large percentage of fine dust which constitutes a most effective filler	Inert
Asphalt		Manufactured to M O T specifications	Highway surfacing	Hard wearing	—
Liquid Bitumens	Bitumen supplied in drums or by bulk delivery	Heavy viscosity 95/115 Medium 65/75 Light 35/45	Applied at 260° and 240° F	Non injurious to fish life	—
Cold Sprays and Grouts	Bitumen emulsion	55% bitumen 62% bitumen	Spread by pressure tanks or applied by hand	Used for patching, spraying and grouting of roads. No heat required	—
A E H DUSSEK, BROMLEY, KENT					
Rubber Roadways	A combination of rubber and asphalt for surfacing, spraying and mixing with asphalt, bitumen or tar	—		An improved form of rubber road construction with pieces of rubber forming part of the aggregate. A rough mat like surface is provided which remains non-skid and resilient throughout its entire thickness and life. Costs little more than ordinary asphalt. Suitable for main road traffic	
DUSSEK BITUMEN & TAROLEUM, LTD, LONDON, E 3					
"Colade"	Bitumen emulsion	—	Surface dressing, grouting, etc. Used straight from drum or pressure spraying apparatus	Non injurious to animal, plant or fish life. No heating on site is necessary	Can be used equally efficiently on dry and damp surfaces
"Aspholeum"	Liquid bitumen	—	Surface dressing. Manufacture of bitumen, macadam, etc	—	—
"Taroleum"	Tar and Tar-bitumen compounds	—	Surface dressing. Manufacture of tar macadam, etc	—	—
"Dulastic"	Expansion joint filling compound		Filling Expansion joints in concrete	Tough, non-brittle rubbery filling	—
"Subbit"	Cold liquid bitumen	—	Surface dressing and sealing stabilized soil roads	Applied cold seals surface immediately	Ensures complete waterproofing of estabilized soil
"Bitite"	Asphalt grouts	—	Grouting wood and sett paving, macadam and packing under tram rails	—	—

PRODUCTS (INCLUDING TRADE NAME IF ANY)	BRIEF DESCRIPTION	STANDARD TYPES AND/OR SIZES	GENERAL USES AND APPLICATIONS	SPECIAL USES AND ADVANTAGES	IMPORTANT INFORMATION CONCERNING PRODUCTS
DUSSEK BITUMEN & TAROLEUM, LTD, LONDON, E 3—*continued*					
"RUBITITE"	Rubber filled asphalt grouts	—	Grouting wood and sett paving, macadam and packing under tram rails	Rubber filling adds toughness and flexibility to matrix	
ENDERBY & STONEY STANTON GRANITE CO, LTD					
MACADAM CHIPPINGS	Syenite Spec Gravity 2 75	All sizes broken stone chippings $\frac{1}{4}$ in grey washed granite sand Granolithic mixtures	Road surfacing Concrete aggregate	—	Light in colour
KERB		All sections of kerb			
SETTS		Setts 4 × 5 in 4 × 6 in 3 × 5 in 4 × 3 4 in		Special long 4 × 6 in setts for road edging	
ENGERT & ROLFE, LTD, LONDON, E 14					
KRAFT UNION PAPER	Two layers Kraft Paper sealed with a waterproofing material (bitumen)	100 yds × 1 yd	Underlining concrete roads	Assists curing	
EXPANSION JOINTING	Hard bitumen on a hessian base	Usually made in strips 6 ft × various widths × required thickness	Used between concrete bays	Prevents cracking of concrete	
EXPANDED METAL CO, LTD, LONDON, S W 1					
'EXPAMET'	Expanded steel made from rolled sheet metal which is cut and expanded into a network of diamond meshes	To B S S 405 and 1221 In sheets of any length longways of mesh up to 16 ft by any length shortway of mesh up to 61 ft	Reinforcement for concrete roads, pavings, tramways, etc	—	—
"EXPAMET" TREBLE-LAYER REINFORCEMENT	A treble mesh of three layers, flat layers top and bottom with a corrugated middle layer of diagonal strands	Ditto	Reinforcement for concrete roads, pavings, tramways, etc	—	—
EXPANDED RUBBER COMPANY, LTD, CROYDON, SURREY					
"RUBAZOTE" EXPANSION ROAD JOINTING	Soft expanded rubber of closed cell structure	*Width* — *Thickness* 5 in — $\frac{3}{8}$ & $\frac{1}{2}$ in 6 in — $\frac{3}{8}$ & $\frac{1}{2}$ in 7 in — $\frac{3}{8}$ & $\frac{1}{2}$ in 8 in — $\frac{3}{8}$ & $\frac{1}{2}$ in 9 in — $\frac{3}{8}$ & $\frac{1}{2}$ in 9$\frac{1}{2}$ in — $\frac{3}{8}$ & $\frac{1}{2}$ in Density 20 lb per cubic foot	Expansion jointing on all types of roads	Non absorbent properties	Cannot absorb water, and therefore cannot disintegrate in frosty weather Regains original thickness immediately after compression
EXPANDITE, LTD, LONDON, N W 10					
"FLEXCELL"	Non extruding fibre expansion joint filler		Joint filler for concrete roads, etc	Has high compressibility and resiliency, and will not extrude	—
"ELASTITE"	Concrete coloured sealing compound for non extruding jointing	—	Applied hot For sealing joints in concrete roads, footpaths, etc	Prevents penetration of water through the joint	Should not be used for sealing bitumen jointing
'TOPSEAL'	Sealing compound	—	For sealing "Flexcell" where a visible black line is unimportant		
FORTICRETE, LIMITED, LIVERPOOL, 10					
"FORTICRETE" PAVING FLAGS	Hydraulically pressed granite concrete	3, 2$\frac{1}{2}$, 2 in in B S S sizes	Street paving, etc	Durability, non-slip, movable	—
KERB STONES	Vibrated granite concrete	B S S sizes	—	—	—

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GAS LIGHT & COKE COMPANY, LONDON, E.C.4					
"BECSTRAY"	Road tar	Conforming to B.S.S. 76 1943	Surface dressing, grouting, tarmacadam, etc. Applied hot	Carpet work	For Type A Tar and Type B Tar. Conforming to Type C Tar
"BECTAPHALT"	Tar bitumen compound (90% B.S.S. Tar plus 10% Residual bitumen)		Surface dressing, grouting, tarmacadam, etc. Applied hot	—	
"BROTOX"	Non toxic tar		Surface dressing, etc. Applied hot		Approved by the Ministry of Agriculture and Fisheries for roads draining into fishing waters
"BECMULSE"	Tar emulsion	Conforming to B.S.S. No. 618	For tack coats, grouting and footpath work. Applied cold	—	
GREATOREX & SON, LTD., MATLOCK					
LUMP LIMESTONE	Hard Derbyshire mountain limestone (coniferous) with high crushing strength	6–9 and 9–12 in	Road foundations		
CRUSHED LIMESTONE	Ditto	All sizes to B.S.S.	Concrete aggregates, chippings for tar spraying and aggregate for rolled asphalt and mastic asphalt for roadways		
TARRED AND BITUMINOUS LIMESTONE	Ditto	All sizes to B.S.S.	Roads, footpaths, drives, school playgrounds, etc.		—
"PATAMAC"	Carefully graded limestone grit coated with specially blended bituminous binder	¾ in fine	Footpaths, yards, school playgrounds and drives. Patching repairs to existing tarmacadam and concrete surfaces	—	It may be stored several weeks prior to using. Provides smooth non-skid surface with pleasing appearance
GEO. GREENWOOD & SONS, HALIFAX					
KERBS AND FLAGS GRANITE CHIPPINGS	Hydraulically pressed concrete	—	—	—	—
HALL & CO., LTD., CROYDON					
WASHED AND GRADED CONCRETE AGGREGATES		—	—	—	—
PIT SAND	—		—	—	—
LIMESTONE			—	—	—
LUMP LIME		—	—	—	—
HYDRATED LIME	—	—	—	—	—
HARDAMAC, LTD., MATLOCK					
BASALT	Olivine basalt, crushing strain 42,000 lb per sq in. Other physical tests of high standard. Particulars on application	All sizes to B.S.S.	Concrete aggregate chipping for tar spraying and aggregate for rolled asphalt and mastic asphalt for roadways, etc.	High physical standards result in exceptional durability and long life	—
'HARDAMAC'	Bitumen coated basalt as above	Ditto	Surfacing of highways, etc.	Ditto	—
'RUGOSITE'	Heavily coated olivine basalt, made by patented process for single coat application	2¼–1½ in 1½–¾ in	Surfacing of highways, etc.	Laid in one coat and provides permanent non-skid surface	Must be laid immediately on road delivery, fresh from plant
HARRISON & BARTON, LTD., SLINFOLD, SUSSEX					
CONCRETE KERB AND PAVING	—	B.S.S. all types vibrated	Roads, paths	—	—
HIGHWAYS CONSTRUCTION, LTD., LONDON, S.W.1					
COMPRESSED ASPHALTIC ROAD SURFACING "MONOLASTIC"	— Rolled asphalt road surfacing	—	—	—	—

PRODUCTS (INCLUDING TRADE NAME IF ANY)	BRIEF DESCRIPTION	STANDARD TYPES AND/OR SIZES	GENERAL USES AND APPLICATIONS	SPECIAL USES AND ADVANTAGES	IMPORTANT INFORMATION CONCERNING PRODUCTS
HIGHWAYS CONSTRUCTION, LTD., LONDON, S.W.1—*continued*					
ROCK NON-SKID ASPHALT SURFACING "MONOMASTIC"	Mastic asphalt road surfacing	—	—	—	—
"MONOCRETE"	Bituminous macadam for road surfacing	—	—	—	—
HILLHEAD QUARRIES, LIMITED, HARPUR HILL, BUXTON					
"SURFACITE" COLD ASPHALT CARPETING	Specially graded and coated with special bituminous binder	All grades from 1½ to ⅛ in	Ideal material for carpeting all classes of roads	—	Provides close textured, durable impervious surface, light in colour and non skid
TARRED BITUMINOUS LIMESTONE	Manufactured from hard mountain limestone aggregate coated with heavy or light tarred or bituminous binder	All grades	All classes of work	—	—
LIMESTONE CHIPPINGS	Manufactured from hard mountain limestone	All grades	Ideal for surface dressing where light surface is required		
GROUND LIMESTONE	98 9% Calcium carbonate	60 70% passing 200 mesh	Industrial and agricultural	—	—
HILLHOUSE QUARRY CO., TROON					
TAR AND BITUMINOUS MACADAMS, CARPETS, ASPHALTS, FILLERS, CONCRETE PRODUCTS	Blue whinstone	All sizes	Road construction and concrete products	—	
THOMAS HILL-JONES, LTD., LONDON, E.3					
"INVICTA" COLD BITUMEN 62%	The ideal medium for cold bituminous surfacing	—	—	—	—
"INVICTA" COLD BITUMEN 55%	Specially designed for cold grouting and spraying	—	—	—	—
"INVICTAK"	A specially designed bituminous emulsion for laying under carpets, etc It will not fat up	—	—	—	—
"INVICTEX"	Cold asphalt carpeting material	—	—	—	—
"INVICTAMIX"	A cold bituminous binder for premixing carpeting material	—	—	—	—
"INVICTA" GROUTS Nos 1, 2, & 3	For hot binding broken granite and surfacing granite setts	—	—	—	—
"INVICTA" G S GROUT	For grouting granite setts				
"INVICTA" W B GROUT	For grouting wood blocks	—	—	—	—
"INVICTA" EXPANSION JOINTING	An elastic bitumen for poured expansion joints	—	—	—	—
"INVICTA" HOT BITUMEN SPRAY	A specially designed hot bituminous binder of great tenacity This material will hold ⅜ in granite chippings for many years	—	—	—	—
"INVICTUMEN"	An all bitumen hot dressing of high quality	—	—	—	—

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THOMAS HILL-JONES, LTD, LONDON, E 3 *continued*					
"INVICTA" HOT COMPOUND	A well balanced hot dressing of dehydrated tar and bitumen	—	—	—	—
"INVICTA" SPRAY	An economical hot dressing of dehydrated tar	—	—	—	—
HINGSTON DOWN QUARRY CO, LTD, LONDON, S W 1					
BROKEN STONE	Granite, macadam, chippings and dust	All sizes to B S S	Road work, civil engineering and building	Stone has high light reflecting properties	
A C W HOBMAN & CO, LTD, LONDON, E C 4					
TARPAVING	—		For playgrounds, etc	—	—
THE HOLMS SAND & GRAVEL CO, LTD, BRISTOL, 1					
"HOLMS"	Sand	—		—	This firm are sand and grit dredger owners A fleet of lorries is maintained and deliveries can be made to any part of Somerset, Glos and Wilts
BRISTOL CHANNEL GRIT	Road dressing			—	
"BIDEFORD" Stone and GRANITE CHIPPINGS	Gravel	All sizes	—	—	
PORTLAND CEMENT FERROCRETE		—	—	—	—
Agents for "CALIMI"	Hydrated lime		—	—	
HOPWOOD BROTHERS, LTD, BAMBER BRIDGE					
"KELMAC"	Bituminous coated limestone	Sizes 2¼ in down to ⅛ in sand carpeting	Roads, paths, etc	—	—
HUTCHINSON INSTRUMENT CO, LTD, ACTON, W 3					
CONTROL AND RESEARCH LABORATORY APPARATUS MECHANICAL AND ELECTRICAL INSTRUMENTS REMOTE INDICATION APPARATUS SPECIAL TESTING INSTRUMENTS SPECIALISTS IN APPARATUS FOR THE ROAD ENGINEERING INDUSTRIES	Penetrometers (Standard Automatic & Miniature) *Viscometers* Ductilometers Thermostatically Controlled Ovens Water Baths, Hot Extractors Melting Point Apparatus, Soil Testing Apparatus, *Electric* Strength Apparatus, Tensile Strength Apparatus, Slump Test Apparatus, etc	To B S S, T P C, I P I and ASTM Specifications *Tubular heaters* lengths 2 to 20 in Banks single to 6 tier	Apparatus for Laboratory control of industry or for research Power station Instruments	Position instrument engineering accurate adherence specification	
HYDREXIT, LTD, LONDON, S W 1					
"HYDREXIT" AQUASIL WATERPROOFER	Integral Waterproofer	In 5, 25, and 40 gallon containers	For all concrete construction	—	—
QUICK SETTER	Concrete accelerator				
"WEATHERIT"	For curing water penetration			For curing water penetration through walls and tunnels, and sub soil insulation	
"EVERLASTIC"	Road jointing	—	For concrete expansion joints	Complete and permanent sealing	—
JUTECOURSE		Yard wide sheets per ton	—	—	—
IMPERIAL CHEMICAL INDUSTRIES, LTD (BILLINGHAM DIVISION,), LONDON, S W 1					
"PIONEER"	Portland cement	1 cwt paper bags	—	—	—
"STREICRETE"	Rapid hardening cement	1 cwt paper bags			

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JAEGER SYSTEM CONCRETE, LTD., GLASGOW, C 2					
Truck-Mixed Concrete	Concrete, to customers' specification, is delivered ready mixed to point where it is required	—	All kinds of concrete work and construction	Speed, consistency, economy, cleanliness	Scientific production, accurate batching and special scales to allow for moisture content enable the supply of concrete to any required specification
E. E. JEAVONS & CO., LTD., TIPTON, STAFFS					
Hot "Compactum" Asphalt	Patent hot asphalt	Base coat 1½ in down. Wearing coat ¾ in down. Wearing coat ⅜ in down	Roads, footpaths, etc.	Long life, upkeep nil	Used on many important main roads, also for lighter traffic
Fine Asphalt	Medium temperature asphalt	Wearing coat ⅜ in down	Ditto	Ditto	Used for carpets and for patching
JERRARD SONS & CO., LTD., GUILDFORD					
Waterproof Concreting Papers	Various grades	In 100 lineal yard rolls	For use in concrete road construction and building	-	In use since laying of the Ministry of Transport's experimental road at Harmondsworth
"Creteprufe" "K 30"	Two papers reinforced with bitumen	Widths 36–60 in			
"Bituprufe" "Herculoid"	Single papers specially treated	Ditto			
JOHNSON'S REINFORCED CONCRETE ENGINEERING CO., LTD., LONDON, S.W.1					
Steel Wire Lattice	Electrically welded reinforcement	17 ft 6 in × 7 ft or shorter lengths to suit site. In rolls up to 120 ft long	For reinforcing concrete roads, etc.	—	—
JOHNSTON BROS. (CONTRACTORS) LTD., DAWLEY, SALOP					
Cast Stone	Manufactured in plain, coloured or Portland concrete, cornolith, Bath, Ornshill or Cotswold	Average weight per cu ft 138 lb	Bridge facings	-	All stone pneumatically dressed to minimize crazing
Cornolith	—	—	For steps, fencing posts, kerbing	—	-
Precast Concrete Kerb Sections	Standard FBS	6 × 12 and 5 × 10 in sections	-	—	
	Combined channel and kerb	12 × 7 in sections. 1 in Bullnosed kerb in 4 × 10 in and 3 × 9 in sections	—	--	—
	Square	12 × 6 in, 10 × 5 in, 10 × 4 in and 9 × 3 in sections			
"Bascrete"	Round Bullnosed Panel fencing	9 × 6 in sections —	—	Any special type of fencing supplied to order	—
JONES, REDFERN & CO., LTD., LONDON, W 8					
"Valltar" Double Coat Process Triple Coat Process	Thin carpet surface	-	For surfacing concrete, asphalt, wood blocks and tarmacadam, etc.	Non-skid surface	—
Tar and Bitumen Compound	—	—		Non-bleeding	Contains 20% bitumen of a specially hard type
"Vallbit"	Road emulsion	Grades "A" & "B"	—	—	—
"Jobit"	Bitumen expansion jointing, etc.	1 cwt drums	—	Resilient, does not crack, waterproof, and will not sweat	Hot and cold processes for flooring, flat roofing, etc.
"V-J" Cast Iron Road Setts	—	6 and 12 in wide × 1 ft. 13 and 24 lbs respectively	For bus stops, street markets, pedestrian crossings, etc.		

PRODUCTS (INCLUDING TRADE NAME IF ANY)	BRIEF DESCRIPTION	STANDARD TYPES AND/OR SIZES	GENERAL USES AND APPLICATIONS	SPECIAL USES AND ADVANTAGES	IMPORTANT INFORMATION CONCERNING PRODUCTS
JONES, REDFERN & CO, LTD—*continued*					
"V J" COMBINED CHANNEL AND KERB	Steel	l'th d'th wide th'k yd in in in 1 3 6 [illegible] 1 4 6 [illegible] 1 3½ 7 [illegible] 1 4 8 ½	—	—	—
T C. JONES & CO, LTD, LONDON, W 2					
REINFORCEMENT FOR CONCRETE CONSTRUCTION	(Bar & Mesh) Design, manufacture and fixing		—	—	
JUDKINS, LTD, NUNEATON					
BROKEN GRANITE AND CHIPPINGS		To B S Specifications	Roadstone and concrete work	High crushing strain	
TARMACADAM	—	Ditto	Roads and paths	—	—
"ARMOURCRETE"	Bituminous topping	⅜–½ in			
KERNER-GREENWOOD & CO, LTD, KING'S LYNN					
"PUDLO" BRAND CEMENT WATERPROOFING POWDER	A fine, dry, white powder for addition to Portland cement in the formation of concrete or sand-and-cement renderings which are thereby made waterproof	Tins each containing 7 lb nett Cartons containing 28 & 56 lb nett weight	—	—	—
KETTON PORTLAND CEMENT CO, LTD, SHEFFIELD					
"KETCO" BRAND	Portland cement	To meet B S S	For all purposes where a high grade Portland cement is required	—	—
"KETTOCRETE"	Rapid hardening cement	—	High strength at early age	For work where greater speed is required than obtaining with ordinary Portland cement	
KETTON WATER REPELLENT CEMENT	Water repellent cement	—	For all purposes	For concreting work which is to be water resisting	
KETTON "WINTER" CEMENT	Ultra rapid hardening cement	—	—	For use in frosty weather and where there is a need for quicker setting and more rapid hardening than is obtainable with rapid hardening cement	—
W H KEYS, LTD, WEST BROMWICH					
"RUBBERYL"	Super tar	—	Surface dressing pre-heat to 200–220 C	Holds ⅜ in chips	
"MASTICOLD"	Bitumen emulsion to B S 434	—	Surface dressing without pre heating	Holds ⅜ in chips	
"PETRASPHALTE"	Grouting and surfacing asphalt		Poured in or applied by squeegee		
"MASTICO"	Binder	—	For hot lay asphalt and bituminous carpets	Pure bitumen	
KING'S ASPHALT, LTD, EXETER					
"COLTRIN" B	Cold bitumen emulsion	55% bitumen	Surface dressing of roads, drives and paths	Laid cold non injurious to fish and plant life	Manufactured in accordance with B S S
"COLTRIN" A	Ditto	62% bitumen	Surface dressing and grouting	Ditto	Ditto
"COLTRIN" M	Stable emulsion	55% bitumen	Soil stabilization and other special uses	Ditto	
"ANGLOSPRAY"	Heavy hot bitumen compound	Laid hot	Surface dressing of important main roads	Produces non skid surfaces Holds ⅜ in chippings with ease	Proprietary brand made to manufacturer's own specifications
"HOTTRIN" T	Ditto	Ditto	Ditto	Ditto Adheres to damp surfaces	Ditto
"ANGLOMAC"	Ditto	Heavy liquid	Binder for manufacture of bituminous macadam and carpet coat materials	Adheres readily to all types of aggregates Non-polishing under traffic	Ditto
"ANGLOPHALTE"	Heavy hot, pure bitumen binder	Semi-solid	Matrix for manufacture of asphalt macadam and carpet coat materials	Produces non-skid surfaces under all conditions of weather	Ditto

All the above materials are manufactured under licence from the Anglo American Asphalt Co Ltd

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LAFARGE ALUMINOUS CEMENT CO, LTD, LONDON, W 1					
"Ciment Fondu" Aluminous Cement	Ultra rapid hardening cement	—	Road foundations, fixing "catseyes", pre-cast work, pipe jointing, etc	Ready for full load within 24 hours of placing. Resistant to attack by sulphates and moorland waters. Waterproof without admixture of waterproofing compounds	Minimises delays on road repairs
THE LANCASHIRE STEEL CORPORATION, LTD, ROAD MATERIALS DEPT, IRLAM, Near MANCHESTER					
Tarred Slag	Selected blast furnace slag, coated with tar	B S sizes or gradings	Road surfacing, etc	For roads carrying all classes of traffic	—
"Tarmac"	Ditto	Ditto	Ditto	Ditto	—
"Seltite"	Selected slag coated with bitumen	⅞–⅜ in, ⅜–⅛ in and other sizes	Wearing coat for heaviest trafficked roads	Hard wearing and non skid surface	—
"Grittite"	Specially graded fine slag coated with bitumen	Brushing in and carpeting grades	Blinding of interstices, and carpeting, footpaths, etc	Sealing coat for road surfaces, but leaving non-skid	—
Dry Slag	Selected blast furnace slag	Graded in various sizes from 6 in downwards to B S	Foundation work, concrete, etc	—	—
Concrete Kerb	Hydraulically pressed	In slag, granite and other aggregates	—	Hard wearing and frost proof	—
LANGLEY LONDON, LTD, LONDON, S E 1					
"Scutan"	A building paper which prevents the water content of the concrete from being drawn away into the sub soil, thus ensuring that the water remains in suspension in the concrete-mix throughout the hardening period	Three grades Nos 10, 14, and 24 to withstand average stresses of 60, 83, and 100 lb per sq in respectively on the Mullen's Test. Length of rolls, approx 111 yd. Standard widths 36, 54, 72 in	All road concreting work	Waterproof "Scutan" prevents sub soil impurities attacking that important bottom inch of concrete before it is matured	The special "Scutan" waterproofing compound is infused both sides of the paper instead of being allowed to impregnate. The internal fibres are protected on both sides by this process, which places the resistance to moisture and other outside agencies just where it is needed
LIMMER & TRINIDAD LAKE ASPHALT CO, LTD, LONDON, S W 1					
Trinidad Lake Asphalt	See *Trinidad Lake Asphalt*, by Attwooll & Broom, pub The Baynard Press, London, S W 9 (See also Section Six)				
LONDON BALLAST CO, LTD, LONDON, W 2					
Graded Aggregates for Concrete	*Washed and crushed shingle*	*2, ½, ¾, ⅜ and ¼ in shingle 3/16 in sand*	*For the production of high grade concrete*	*High crushing strength tests, or acceleration of setting*	*Graded aggregates can be supplied to meet the most exacting specification*
GEORGE LOVEGROVE & CO, LTD, MATLOCK					
Lump Limestone	Hard Derbyshire mountain limestone (Carboniferous) with high crushing strength	6–9 in and 9–12 in	Road Foundations	—	—
Crushed Limestone	Ditto	All sizes to B S S	Concrete aggregates, chippings for tar spraying and aggregate for rolled asphalt and mastic asphalt for roadways	—	—
Tarred and Bituminous Limestone	Ditto	All sizes to B S S	Roads, footpaths, drives, school playgrounds, etc		
McCALL & CO (SHEFFIELD), LTD, SHEFFIELD					
"Matobar"	Electrically-welded fabric	Long or square mesh	Reinforcement of concrete roads, etc	—	—
A & F MANUELLE, LIMITED, LONDON, E C.3					
Granite Street Kerb	—	*Width* × *Depth*: 6 in × 12 in; 8 in × 12 in; 12 in × 6 in; 5 in × 10 in; 10 in × 5 in; in random lengths	For street kerbing and channelling	Indestructible and especially suited for heavy commercial areas	—

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A. & F. MANUELLE, LIMITED, LONDON, E.C.3 *continued*					
GRANITE SETTS		5 in × 4 in 4 in × 4 in 3 in × 5 in 3 in × 6 in 4 in × 5 in 4 in × 6 in in random lengths	For street paving and channelling	Especially suited for horse or iron tyred traffic in dock areas, railway yards	
GRANITE CHIPPINGS		⅜, ½, ¾, 1, ⅛ in gauge gritty sand (or gradings of above sizes)	For tar spraying, granolithic flooring, road carpeting, concrete aggregates, etc	Extremely durable and non-skid surfaces	—
EDWARD MARSHALL, LTD., LONDON, W.1					
TERRAZZO	Paving and wall finishes of subways	—	For major road and pedestrian subways	—	
MASON'S PORTLAND CEMENT CO., LTD., CLAYDON, Near IPSWICH					
PORTLAND CEMENT	Highest quality		Concrete work generally	—	—
"METALBOND" RAPID HARDENING CEMENT	An ultra cement with rapid hardening properties	—	—	Where speed of hardening and early removal of shuttering is important	
MATT-SURFACE ROADS, LIMITED, LONDON, S.W.1					
"AZTEC"	Pure petroleum cold emulsified bitumen manufactured to B.S.S. 434 (1935)	*Grade* "A" containing 62% bitumen	For surface dressing and grouting	Not suitable for use through pressure sprayers	No expensive plant is required *for application* Can be used under weather conditions when use of hot materials would be impossible
		Grade "B" containing 55% bitumen	For surface dressing and grouting	Especially suitable for use through pressure sprayers	
		"*Carpetgrip*" low viscosity emulsion	For use as a tack coat	Especially useful under cold asphalt and other tarred or bituminous carpets	Non toxic
		"*Aztec*" 30% emulsion	Especially useful for revitalizing fretting road surfaces	Great penetration powers. Does not leave thick bitumen coating on road surface	Ready for use, cold, as delivered
		"*Aztec*" mixing emulsion	Manufacture of precoated chippings and mixing suitable aggregates and soil stabilization	A slow breaking emulsion of great stability	These emulsions are not chemically impaired by slight frost
"TARAZITE"	Proprietary tar compound	—	Hot tar compound for application at 240°F to 260°F	A surface dressing material of first class quality	—
"AZTECMATE"	A fine, cold Asphalt	Manufactured from slag graded ⅛ in to dust and our special bituminous matrix	For patching almost any type of existing road surface and over all surfacing	Laid cold and when used for patching no hacking out necessary. Can be laid to a feather edge	Will stock for 3 months. Requires no surface dressing. Long life and slow wearing. NON-SKID
METROPOLITAN CONCRETE WORKS, LTD., EAST MOLESEY					
"METROGRAN" PAVING SLABS	Hydraulically pressed	To B.S. 368	—	—	—
ROAD KERBS	Made by high speed vibratory process	To B.S. 340	—	—	—
MIDGEHOLME GRANITE QUARRIES, CARLISLE					
ROADSTONE (foundation and broken), CHIPPINGS, SETTS, AGGREGATE, TARRED GRANITE	Granite	12 in foundation to ⅛ in chippings	Roadstone, concrete aggregate, headstones, curbs, road setts	—	—
THE MOUNTSORREL GRANITE CO., LTD., LEICESTER					
MACADAM	Grano-diorite	All sizes of broken granite and chippings	Road surfacing	Light in colour	Colour and crystalline structure give excellent visibility when used for road surfacing
CHIPPINGS	Spec. Gravity 2.68	⅛ in clean chippings, washed granite sand	Concrete aggregate	Pink	—
MOUNTSORREL TARRED MACADAM CO., LTD., LEICESTER					
"TARGRANIT"	Tarred Leicestershire granite from Mountsorrel and Enderby Quarries	All sizes	Road surfacing. Footpaths	—	The tar used is distilled by the Company and is under constant laboratory control. Viscosity can be varied to suit local conditions
"MACAMIT"	Bituminized granite	All sizes	Thin carpeting coats	Low spec. gravity gives excellent covering capacity	In wear loses surface bitumen, giving resultant surface of light coloured non-skid granite

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THE NEUCHATEL ASPHALT CO., LTD., LONDON S W 1					
Compressed Natural Rock Asphalt	—	British Standard Specification	—	For roads and footways	-
Rolled Asphalt	—	Ditto	–	Ditto	
Mastic Asphalt	--	Ditto	—	Ditto	-
"Nocomac" Non skid Thin Carpet	--	-	—	For roads	—
Tarmacadam and Tar Paving	-	Ditto	—	Roads, footways, play grounds, tennis courts, car parks etc	-
NONSKID ROADS, LTD , LONDON, S W 1					
Asphalt for Surfacing Roads and Footpaths	Special fine asphalt which gives a "sandpaper" non-skid surface			Can be laid by unskilled labour	Eminently suitable where only a thin regulating surface is required
Licensees for "Carpave Fine Toppings"	—		—	-	—
NORCON, LIMITED, LONDON, S W 9					
"Norcon" Reinforced Concrete Path Edging	-	1 in × 4 in × 3 ft 1½ in × 5 in × 4 ft 2 in × 6 in × 6 ft	For protecting the edges of paths in lieu of timber	Interlocking and self setting. Practically indestructible. Costs less to fix than timber, cannot warp or rot and gives perfect alignment	--
"Norcon" Reinforced Concrete Stayblocks	--	Light 12 × 15 × 3 in Medium 15 × 20 × 3½ in Heavy 17 × 25 × 5 in	For securing stay wires of posts (telephone and electricity overhead lines)		Easy to handle most secure form of anchoring, indestructible
Also—Concrete Spur Posts, Fencing Posts, Kerbing, Paving					
NORTON LIMEWORKS, LTD , SWANSEA					
Asphalt Paving, Macadam	Bitumen and tar	—	—	—	-
Mastic Asphalt					
NOTTER RIVER QUARRIES (1936), LTD , LONDON, S W 1					
Broken Stone Coated Stone	-	All standard grades to B S S	Road and building work	—	-
Concrete Blocks and Slabs	—	All standard grades to B S S	Road and building work	-	—
THE OLD SILKSTONE CHEMICAL WORKS, LTD , Near BARNSLEY					
Refined Tar	Best coke oven refined tar product	—	For general purposes and road spraying, to be applied hot Any desired viscosity		
"Silkmac"	Proprietary road-spraying material (registered)	—	Ditto	—	
PENARTH CONCRETE CO (1927), LTD , LOWER PENARTH, GLAM					
Concrete Paving and Kerbing	Hydraulically pressed to B S S	Standard sizes	Street paving Road works	Non slip	Pennant aggregate.
PENLEE QUARRIES, LTD , LONDON, S.W.1					
Penlee Macadam, Chippings and Dust	Dry and coated with tar and bitumen	2¼, 1½, 1, ¾, ½, ⅜, ¼, ⅛ in, ⅛ in -dust, 1/16 in -dust	Aggregate for concrete asphalt and tarmacadam Broken stone for filter media, etc Chippings for tar spraying, etc	-	Specially high crushing stress, viz 68 850 lb per sq inch
Penlee Filler	-	Fine grade, 80% passes 200 mesh Superfine, 95% passes 200 mesh.	Filler for asphalt and other bituminous compounds	—	-
PENTEWAN DOCK & CONCRETE CO , LTD., CORNWALL					
Pentewan Sand	—	Graded ⅛–⅜ in 1/16 in. down ⅛ in special grit	Concrete roads and sewers	High compression Special grit for asphalt work	Free from all impurities All retained 100 mesh
Pentewan-Gwithian Sand	—	—	—	High abrasive tests	—

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POWELL DUFFRYN, LTD., BY-PRODUCT SALES, CARDIFF					
"SYNTHATAR"	A synthetically refined tar containing 10% of bitumen	Sold in 40 gallon containers — road and rail tank wagons	Two grades 1 For the manufacture of tarmacadam 2 For the surface dressing of roads	Non toxic to fish life	—
PREMIER BITUMEN & ASPHALT CO., LTD., LONDON, E 15					
"ASPHALTMAC"	Heavy bituminous matrix	Surfacing or grouting grades, also grades for grouting setts or wood blocks	Surfacing all classes of roads	Long life and non skid	Rubberized under patent
"COLDRESS"	Bituminous emulsion	Spraying or grouting grades	Surfacing roads, drives or footpaths	Applied cold	Rubberized under patent.
"ROADRESS"	Pure asphaltic bitumen	Spraying, grouting or mixing grades	Surface dressing all types of road	Applied hot Will hold ⅞ in. chippings and give exceptionally long life	Rubberized under patent
"ELASTREX"	Bituminous compound	Black or cement grey colours	Expansion joint filling		Rubberized under patent
WILLIAM PRESTWICH & SONS, LTD., Near SHEFFIELD					
'PRESTPHALT'	Bituminous "non skid" surfacing material	Granite slag or limestone aggregate	Road topping or carpeting	Can be laid direct on setts or on existing roadways	Requires no surface dressing for at least three years
"PRESTWICH" TARMACADAM	Tarred granite Tarred Derbyshire mountain limestone	3 4 2½, 1½, 1, ¾, ½, ⅜ in and grit, or graded as required to B S or Government specifications	Road surfacing	Durable and reliable	Accepted and used by Government depts, county, borough, urban and rural councils, and public contractors
"PRESTWICH ROAD STONE AND SLAG	Dry and uncoated road materials	Lump, pitching, blinding and rubble All broken and screened sizes as above	Ditto	Ditto.	Ditto
"PRESTWICH" PRECAST CONCRETE	Granite, limestone or quartzite aggregates	Kerbs slabs, posts, fencing, gas lamp standards	For roads and paths, etc	Exceptionally high crushing strength obtained by test	Ditto
RESMAT SALES, LTD., LONDON, S W 1					
RESMAT"	Patent cold asphalt surfacing material	Sandpaper carpet Rough carpet	Surfacing of roads footpaths cycle tracks etc Applied as ½ in or ¾ in carpet	A hard wearing surfacing which retains its non skid characteristics for its entire life Does not require surface dressing at any time Ideal patching material	Has a minimum life of 10 years under heavy traffic
RIBBLESDALE CEMENT, LTD., CLITHEROE					
"RIBBLE"	Portland cement		Road construction bridge-building etc		Output 150,000 tons per annum delivered by road or rail
"VELOCRETE"	Rapid hardening cement		—	—	-
ROADS RECONSTRUCTION (1934), LTD., FROME, SOMERSET					
LIMESTONE GRANITE	Clean and well-graded material	To B S S	For all types of road construction, tarmacadam manufacture and concrete aggregate	-	Full technical supervision to ensure consistency of grading and quality
TARMACADAM	—	To B S S	Roads, runways, parade grounds, footpaths, play grounds, etc		Full technical supervision to ensure consistency of grading and quality
'SAFETPHALTE"	A graded mixture of granite and limestone aggregate coated with fluxed residual bitumen	⅜ in graded and ¼ in graded	Carpet coat or wearing course	Non slippery	Surface dressing not necessary for 5 years
DAMMANN ASPHALT	Fine cold asphalt	To Dammann Asphalt Co's Specification	Thin wearing carpet for roads, etc	Non slippery Can be laid cold	Can be stored and used as required Surface dressing not necessary for many years
PAVING SLABS KERBS AND CHANNELS	Concrete	—	—	—	—
THOMAS ROBERTS (WESTMINSTER), LTD., LONDON, S W 1					
DRY, TARRED AND BITUMINOUS SLAG		To B S S	—	—	
DRY TARRED AND BITUMINOUS GRANITE	-	Ditto	—		—

PRODUCTS (INCLUDING TRADE NAME IF ANY)	BRIEF DESCRIPTION	STANDARD TYPES AND/OR SIZES	GENERAL USES AND APPLICATIONS	SPECIAL USES AND ADVANTAGES	IMPORTANT INFORMATION CONCERNING PRODUCTS
THOMAS ROBERTS (WESTMINSTER), LTD, LONDON, S.W 1—*continued*					
Dry, Tarred and Bituminous Limestone	—	Ditto	—	—	—
Biro-phalte Fine Asphalt Carpeting	A fine cold asphalt carpet	Special type for footpaths and play grounds	For surfacing highways including setts and wood block, playgrounds and footpaths	Can be stored and laid cold	-
Washed and Screened Concrete Aggregates	Specially washed and graded	To B S S			Delivered in London area Surrey, Bucks, Northants and Beds, etc
Granite Kerbs and Setts		—		—	-
Granite Concrete Kerbs, etc	—	—	—		—
"Biro tar" Surface Dressing Material	A refined tar	—	For all surface dressing work and for manufacture of approved tarmacadam	Prevents stripping and oxidization of tar, giving longer life	Incorporates a special plastic material
Birovia Bituminous Emulsion	—	To B S S	For surface dressing and grouting	Laid cold, no appliances needed	-
"Redgra" Surfacing for Tennis Courts and Playgrounds	A material giving a pleasing pink surface		For surfacing tennis courts and playing fields	Requires the minimum of attention and maintenance	—
THE ROBINSON WAXED PAPER CO, LTD, BRISTOL					
"Conlay" Concreting Paper	Extra strong impregnated kraft paper to withstand 60 lb Mullens Bursting Test, as laid down in B S Specifications	100 yd rolls, 40, 50 and 60 in	As a covering protection from frost, heavy rain and hot sunshine As an underlay, preventing cracking or powdering Insulation protection from sub base liquids		Highly efficient and low in cost
THE RUBEROID CO, LTD, LONDON, W C 1					
Ruberoid "C & E" Jointing	Made from durable water and weather resisting bitumens and containing cork granules	3 ft lengths, ½, ¾, ⅞ and 1 in thick	For concrete and wood block roads, and aerodrome runways	For concrete coast defence work	
Ruberoid Concreting Paper	Strong bitumenized paper	In rolls of 1000 sq ft 36 in wide	For use on road bed under concrete		—
SADLER & CO, LTD, MIDDLESBROUGH					
Road Tar	To B S No 76 1943	—	Spraying, grouting Manufacture of tarmacadam and dense tar surfacings	—	—
"Quartzphalte"	Proprietary binder for hot application	—	—	—	—
"Eaubit"	Bitumen emulsion cold application	62% & 55% bitumen content B S No 434	Spraying and grouting roads and footpaths Tack-coat for asphalt and macadam	No heat or plant required	—
SAL-FERRICITE & TRADING COMPANY, LTD, LONDON, S.W 1					
"Sal-Ferricite" Metallic Hardener	Metalized powder for concrete hardening, etc.	1 cwt	For use in concrete floors where heavy trafficking and abrasion occurs	Renders floors waterproof and hardens against heaviest of trucking Considerable reduction in maintenance costs.	Floors laid with this product will last ten to fifteen times longer than the normal concrete floor
"Sal-Ferricite" Waterproofing Liquid No 1	Waterproofing Liquid for use with concrete or cement	1, 5, 10, and 40-gallon	For rapid hardening of concrete and waterproofing of brickwork, etc, when used with cement	Gives a fine waterproof result Can be used in frosty weather without any risk of damage by frost	Concrete roads laid with this liquid can be opened to traffic in any time down to four hours after the road has been laid Porous brick or concrete walls can be made permanently waterproof.
"Sal-Ferricite" Waterproofing Liquid No 2	Waterproofing liquid for use against water bursts, etc	1, 5, 10, and 40-gallon.	For use against concentrated jets of water bursting through porous concrete, brick work, etc	Leaks, cracks, etc, can be sealed by plug made of cement and this liquid	Instant sealing and making watertight of leaks, etc where water is coming through under pressure Manholes can be pointed and defective joints sealed This liquid makes Portland cement set in 10-15 seconds.

PRODUCTS (INCLUDING TRADE NAME IF ANY)	BRIEF DESCRIPTION	STANDARD TYPES AND/OR SIZES	GENERAL USES AND APPLICATIONS	SPECIAL USES AND ADVANTAGES	IMPORTANT INFORMATION CONCERNING PRODUCTS
SCIENTIFIC ROADS (NORTHERN), LTD, SHIPLEY, YORKS					
"BITRIN"	Specially prepared bituminous compounds, hot and cold	—	Road surfacing dressing, grouting and tar macadam	—	—
TARRED AND BITUMINOUS ROAD STONE	—		Road construction, repairs and maintenance	—	—
"TERRIPHIL" BITUMINOUS ASPHALT (HOT)	—		Road construction repairs and maintenance	—	
"TERRIPHIL" CARPET COATING MATERIAL	Cold asphalt	—	Road construction repair and maintenance	—	—
SCIENTIFIC ROADS (WESTERN), LTD, CHESTER					
"BITRIN" HOT SPRAY		40 gallon barrels	Road surfacing dressing	Non poisonous to plant and fish life	—
"BITRIN" "X"	—	40 gallon barrels	Road surfacing dressing	Contains bitumen	—
"BITRIN" COLD EMULSION		40-gallon barrels	Road surfacing dressing	Will not disintegrate in normal frosty weather	—
ASPHALTIC "TERRIPHIL"	—	—	Road surfacing dressing	Asphaltic for roads and carriageways	—
TARRED "TERRIPHIL"	—	—	Road surfacing dressing	Tarred for footpaths	—
SCOTTISH TAR DISTILLERS, LTD, FALKIRK					
ROAD TARS	To B S 76	Spray, grout and mixing grades	Tarmacadam and surface dressing	—	—
"TARTAC"	Specially blended proprietary tar	Spray, grout and mixing grades	Tarmacadam and surface dressing		—
"CHONTAR"	Tar-bitumen compound	Spray, grout and mixing grades	Tarmacadam and surface dressing	—	—
"COLD CHON"	Bitumen emulsion to B S specification	Spray and grouting grades	Spraying, grouting and patching	No heating required	—
"CHONIX"	Bitumen emulsion to B S specification	Premix grade Spray grout and mixing grades	Playgrounds, footpaths etc	No heating required	
CHONBIT	Liquid bitumen	—	Tarmacadam and surface dressing	—	—
SEALOCRETE PRODUCTS, LTD, LONDON, W 6					
"SEALOCRETE" METALLIC HARDENER	Metallic compound mixed with cement	Packed in 1 cwt sacks	For hard and dustless roads, pavings, etc	—	—
"SEALATONE" LIQUID COLOURS	Light, middle or dark red, blue, green, buff, black, marigold, brown	Packed in 1 gallon packages	For cement, concrete, rough cast, etc	Increases density and uniformity 25 50 %	1 gallon sufficient to colour 1 cwt cement
SORBO, LTD, WOKING					
"SORBO"	Sponge rubber expansion jointing material	—	For concrete roads, etc	—	—
THE SOUTH COAST CAST CONCRETE CO, LONDON, S W 19					
"SOUTHCRETE" KERB, PAVING, FENCE POSTS, PATH EDGING, BLOCKS, ETC	Precast concrete products	To all B S and trade requirements	For roads and public works	Long life and economy, in lieu of steel, iron and timber	—
SOUTH METROPOLITAN GAS COMPANY, LONDON, E C 4					
"METRO" ROAD TAR	Guaranteed to comply to B S 76: 1943 and the B S I certified mark	—	For application to roads		—
"METRIX"	Specially prepared binder for tar carpets	—	For tar macadam manufacture	—	—

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PRODUCTS (INCLUDING TRADE NAME IF ANY)	BRIEF DESCRIPTION	STANDARD TYPES AND/OR SIZES	GENERAL USES AND APPLICATIONS	SPECIAL USES AND ADVANTAGES	IMPORTANT INFORMATION CONCERNING PRODUCTS
SPUNGROOVE, LTD, LONDON, S W 1					
"SPUNGROOVE" REINFORCEMENT FABRIC	Made from high tensile twisted sq rods	Standard size sheets 15 ft × 7 ft 6 in Supplied in sheets up to 25 ft long and up to 8 ft wide	Road reinforcement	Slab reinforcement, easily laid by unskilled labour	Can be made to any weight per square yard to suit all requirements
THE SQUARE GRIP REINFORCEMENT CO, LTD, LONDON, S W 1					
"SQUARE GRIP" MESH REINFORCEMENT "SQUARE GRIP" CONCRETE LINING PAPER "SQUARE GRIP" EXPANSION JOINTING "SQUARE GRIP" WORK-HARDENED BARS "SQUARE GRIP" BEAM WRAPPING REINFORCEMENT	—	From 3-17 lb per square yard	Concrete roadways, etc	—	—
STAFFORDSHIRE CHEMICAL CO (1917), LTD, STOKE-ON-TRENT					
ROAD TAR	Quality complies strictly with B S and B R T A specifications	—	Spraying of roads and tar macadam	—	—
THE STANTON IRONWORKS CO, LTD, Near NOTTINGHAM					
SLAG TARRED	Selected blast furnace slag to B S 1047 1942	Tarred rejections and all sizes from 2½ in to ⅛ in	High-grade tarmacadam	—	—
DRY	Ditto	Hardcore 4 × 9 in and crushed sizes varying from 4 6 to ⅛ in	Lump slag for road foundations Crushed sizes for road making purposes	Dry slag for filter bed media and concrete aggregate	
"STANTOMAC"	Bituminous coated slag for bottom coats and bituminous carpet to B S 802 1945	2½ in down ¼ to ⅛ in	Bottom coat and bituminous road carpets	Hard wearing, long life	—
CONCRETE KERBS	Manufactured by "Vibrator" process to B S 340 1936	5 × 10 × 30 in and 6 × 12 × 30 in radius to B S S	—	—	—
CONCRETE PAVING SLABS	Hydraulically pressed to B S 368 1936	3 × 2 ft, 2 ft 6 in × 2 ft, 2 × 2 ft, 1 ft 6in × 2 ft, 1 × 2 ft, thickness, 2-2½ in	Pavements, etc	Non-slip finish	—
STARK & DOBBIE, GLASGOW, C 2					
CONCRETE AGGREGATES	Whinstone	3 in to ⅛ in	—	—	—
TARMACADAM	Whinstone	3in to ⅛in			—
STEVE'S EMULSIONS, LTD, LONDON, S W 7					
"STEVEMULSION"	Pure bitumen emulsion	55% and 62% bitumen content	Surface dressing, grouting, patching	Used cold No fuel required Can be sprayed, brushed or squeegeed on to surfaces	Complies with latest B S S
STEWARTS AND LLOYDS, LTD., LONDON, W 1					
STEEL TUBULAR MATERIALS AND THEIR ASSOCIATED FITTINGS AND CONNECTIONS "S & L"	Welded and seamless steel tubes Oiled painted, galvanized, coated, lined or sheathed with bituminous protections	Plain ends ⅛ to 72 in Screwed and socketed up to about 24 in Spigot and socket for lead and yarn, 2"—72"	Conveyance of Air, Gas, Oil (including well boring) Steam, Water (including well boring) Sewage	Cylinders and similar types of vessels Aerial masts, rollers and other mechanical purposes Fabricated tubular structures of all types from fencing and gates to load carrying booms or jibs	Steel tubes are made to standard external diameters and thicknesses, and it is recommended that these be adopted wherever possible Particulars will be supplied on request

PRODUCTS (INCLUDING TRADE NAME IF ANY)	BRIEF DESCRIPTION	STANDARD TYPES AND/OR SIZES	GENERAL USES AND APPLICATIONS	SPECIAL USES AND ADVANTAGES	IMPORTANT INFORMATION CONCERNING PRODUCTS
STEWARTS & LLOYDS, LTD, LONDON, W 1—*continued*					
	According to service and requirements	Sleeve joints or ends bevelled for welding all sizes up to 72 in Flanged joints all sizes up to 72 in Victaulic joints up to about 24 in (or larger if required) Johnson couplings, all sizes up to 72 in	Structural work, including Flag poles Poles Tramway transmission lighting, trolley, scaffolding, clothes poles, handrailing, footbridges	General advantages strength reliability with minimum weight and low cost of maintenance	Technical assistance will be gladly given in connexion with any problem in which steel tubes may be used
STONEYCOMBE LIME & STONE CO, LTD, NEWTON ABBOT, DEVON					
Limestone Tar Macadam		All sizes	For concrete aggregate	—	—
A STREETER & CO, LTD, GODALMING					
Pre-cast Concrete Kerbs	Granite and shingle aggregates	10 × 5 in and 12 × 6 in			
R SUMMERSON & CO, LTD, BARNARD CASTLE, CO DURHAM					
Blue Granite	—	All sizes	Roadstone and concrete aggregate	—	
THOMAS SWAN & CO, LTD, CHELTENHAM					
"Wetfix"	An oil admixture mixable with any tar or bitumen conforming to B S S and in no way affecting these specifications		—	Allows bitumen or tar to adhere permanently to wet aggregates during inclement weather and improves adhesion on dry aggregates	
TAR DISTILLERS, LTD, LONDON, N W 1					
Refined Tar for Road Work					
TAROADS, LTD, LONDON, E C 4					
"Superphalt" and Tarspraying of all Descriptions	—		For the spraying and gritting of country roads	—	This firm has a fleet of tankers for this work
TARSLAG, LTD, WOLVERHAMPTON					
Asphalt Concrete Stone	Asphalt tarmacadam Aggregates for concrete, chippings for surface dressings precast concrete goods	—	—	—	—
T S THOMAS & SONS (LYDNEY), LTD, GLOS					
Tarmacadam Tarpaving Roadstone Concrete Aggregates	Fine grained dolomitic limestone	All sizes to B S 63 1939 Special gradings on request	For all modern roadmaking and engineering duties	Has excellent cementation value	—
TONFANAU GRANITE QUARRIES, LTD, TOWYN, MERIONETHSHIRE					
Dry and Tarred Roadstone	Granite	2½, 2 in Macadam 1½-⅜ in graded ⅝, ½, ⅜, ¼, ⅛ in Chippings Granite dust	Road making concrete work	—	—
TRELUGGAN (CORNWALL) QUARRIES, LTD, LONDON, S W 1					
Broken Stone Coated Stone Concrete Blocks		All standard sizes to B S S	Roads, civil engineering and building	—	—
"TWISTEEL" REINFORCEMENT, LTD, SMETHWICK, STAFFS					
"Wirfweld" Reinforcement Fabric	Hard drawn wire welded at all intersections	Flat sheets 17 × 7 Rolls 240 × 7 ft 180 × 7 ft 150 × 7 ft according to weight	Used in road slabs and reinforced concrete structures, etc	Sheets and rolls can easily be cut to special sizes on sites	Conforms to B S 1221 Part "A"

PRODUCTS (INCLUDING TRADE NAME IF ANY)	BRIEF DESCRIPTION	STANDARD TYPES AND/OR SIZES	GENERAL USES AND APPLICATIONS	SPECIAL USES AND ADVANTAGES	IMPORTANT INFORMATION CONCERNING PRODUCTS
"TWISTEEL" REINFORCEMENT, LTD, SMETHWICK, STAFFS—*continued*					
"TWISTEEL" REINFORCEMENT FABRIC	Cold twisted square rods, welded or interwoven with edges welded	Flat sheets only Made to size to suit requirements	Used in road slabs and reinforced concrete structures, etc	Natural spiral bond throughout	Conforms to B S 1221 Part "B"
"TWISTEEL" (SQUARE TWISTED) REINFORCING BARS	Cold twisted square bars	Cut to lengths	Reinforced concrete structures	Natural spiral bond throughout	Conform to B S 1144
"COVERBOND" (TWIN TWISTED) REINFORCING BARS	Cold twisted twin round bars	Cut to lengths	Reinforced concrete structures	Natural spiral bond throughout	Conform to B S 1144
UNIVERSAL RUBBER PAVIORS, LTD, MANCHESTER					
PATENT RUBBER PAVING	Rubber attached permanently to concrete base blocks	9 × 4½ in	Street surfacing	Long life, absence of repairs, non-skid, dustless, even surface absorbing noise and vibration	—
THE VAL DE TRAVERS ASPHALTE PAVING CO, LTD, LONDON, E C 4					
"VALCHROME"	Coloured asphalt	—	—	—	—
"VALCO"	Asphalt bricks	—	—	—	—
"VALCOPHALT"	Bituminous grout	—	—	—	—
"VALCOSPA"	Road surfacing material,	—	—	—	—
"VALDEX"	Expansion joint compound	—	—	—	—
"VALDOCRETE"	Hard mastic asphalt	—	—	—	—
"VALDOMAC"	Grouted macadam	—	—	—	—
"VALTERRAZZO"	Coloured asphalt	—	—	—	—
THOS. W WARD, LTD, SHEFFIELD					
LIMESTONE	Hard limestone (dry, tarred and bituminous)	Sizes to appropriate B S S	Broken stone and chippings Tarred and bituminous roadstone Concrete aggregates Asphalt filler	—	—
GRANITE	Welsh granite (dry, tarred and bituminous)	Sizes to appropriate B S S	Broken stone and chippings Tarred and bituminous roadstone Concrete aggregates Asphalt filler	—	—
SLAG	Selected old blast-furnace slag and suitable new slag	Sizes to appropriate B S S	Roadstone (tarred, bituminous and dry)	—	—
	Old slag deposits	—	Hard dry material up to 9 in suitable for foundation for roads, paths, etc	—	—
"DUROGRIP"	Special thin bituminous carpets with slag, granite or limestone aggregates	1, ½, ¼ in	For the final surfacing of roads, footpaths, etc	For thin carpets on foundations which may be new tarmacadam, water bound macadam, old tarmacadam and old stone setts or wood paving	"Durogrip" surfacing does not need treatment for several years, is "non-skid" and may be laid by any average skilled spreader
WEST OF ENGLAND ROAD METAL CO, LTD, LONDON, S.W 1					
BROKEN STONE COATED STONE	}	All standard grades to B S S	Roads and civil engineering and building	—	—
THE WHITWICK GRANITE CO, LTD, LEICESTER					
"BIROPHALTE"	A first class hard granite used as the base for a carpet coat with (in normal times) "Birovia" asphalt binder	½ in graded, and also "Birophalte Fine" which has a sandpaper finish.	Surfacing trunk roads and other roads where a long life is required	Non-slippery surface	The plant has a special grading device which ensures even grading throughout all products
BITUMINOUS GRANITE CARPETS	The normal type of carpet coat or bottom coat with standard bitumen binder	To B S sizes, or graded	Surfacing trunk roads and other roads where a long life is required	Non-slippery surface	—

PRODUCTS (INCLUDING TRADE NAME IF ANY)	BRIEF DESCRIPTION	STANDARD TYPES AND/OR SIZES	GENERAL USES AND APPLICATIONS	SPECIAL USES AND ADVANTAGES	IMPORTANT INFORMATION CONCERNING PRODUCTS
THE WHITWICK GRANITE CO., LTD., LEICESTER *-continued*					
Tarred Granite	Any grade of Whitwick granite mixed with first quality tar binder	To B.S. sizes or graded	Surfacing trunk roads and other roads where a long life is required	Non-slippery surface	—
Broken Stone and Granite Chippings	—	To B.S. sizes, or graded	Concrete aggregate or surface dressing	Non-slippery surface	—
WIRKSWORTH QUARRIES, LTD., INNS & COMPANY, LTD., LONDON, N.1					
Hot Rolled Asphalt	To B.S.S.	All sizes	Road surfacing, aerodrome runways, platforms, etc	—	-
Cold Asphalt	Ditto	Ditto			
Bituminous Macadams	Ditto	Ditto	Road surfacing tennis courts, footways, etc	-	—
"Nondress" Bituminous Granite	To B.S.S. veneer carpet	¾ in graded	Road surfacing, etc	—	-
Granite Tarmacadam, Limestone Tarmacadam, Gravel Tarmacadam	To B.S.S.	All sizes	Road surfacing, footways, etc	—	—
Pit Sand Washed, Sand Washed, Shingle, Washed Ballast, Hoggin	-	All grades	Concreting, building roadways, footways, etc	—	
WOODBURY QUARRIES, WORCESTER					
Road Stone					
Asphalt Carpeting Material, Tarmacadam					

DRAINAGE FITTINGS

Manhole Covers

Many undertakers of public service supplies, e.g., Post Office (telephones), electricity, water, sewerage, etc., have the statutory right to place below the surface of the highways such structures as manholes, junction boxes, and the like, access to which is obtained by means of a removable cover. The design of such covers is an important matter since the comfort of the public is affected by the behaviour of the cover under traffic, e.g., there should be an absence of noise as well as an absence of movement and rocking which must result in wear. Highway engineers, as well as engineers to statutory undertakings, will no doubt find it of advantage to keep themselves fully informed as to developments in manhole cover design.

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ALEXANDER PRODUCTS, LTD., STOKE BISHOP, BRISTOL, 9					
Concrete Surface Drain Blocks	—	Standard unreinforced, Standard reinforced, Rubber surfaced	For general use	Reinforced for heavy duty. The perfect drain block for roads and yards	—
Kerb Surface Drain Blocks	—	—	—	Reinforced type combined kerb and channelling	A most efficient drainage system
BROOKES', LTD., HALIFAX					
"Nonchoke"	Porous drain pipes	Inside diameter 3, 5½, 9, 12, 15, 18, 21 and 24 in	For land and surface water drainage	—	—
DEVON CONCRETE WORKS, LTD., BARNSTAPLE					
"Devon" Concrete Pipes	Collar type, spigot and socket (self-invert) joints	Numerous sizes from 6 to 36 in internal diameter	—	Male and female ends designed to give a self centering and true invert	—
"Devon" Rainwater Causeway Drainage Ducts	-	In short lengths up to 3 ft. Overall size of duct—8 in wide × 4 in high	—	Can be adjusted to suit any width of pavement	—

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DEVON CONCRETE WORKS, LTD., BARNSTAPLE—*continued*					
"Devon" Road Gullies	Concrete with glazed, stoneware or concrete outlets	Internal diameter from 12–18 in. Supplied with 4 or 6 in. diameter outlets. 36 in. diameter chamber with 30 in. shaft or 42 in. diameter chamber with 27 in. shaft or other sizes 32 in. dia. and upwards supplied		—	—
"Devon" Manholes	Concrete	—	—	—	—
"Devon" Valve Chambers	—	—	—	Can be removed intact for repairs when necessary	—
"Devon" Tubes	Concrete	Internal diameters from 4–72 in.	Surface water drainage, etc.	—	—
DOVER ENGINEERING WORKS, LTD., LONDON, S.W.1					
Elkington "Gatic" Manhole Covers	Continuous metal to metal contact of all seating surfaces, both vertical and horizontal, of cover to frame. Equal to machine tool finish	Up to 36 × 36 in. *clear opening*. Also available any length of open up to 4 ft. without centre bar, over this span by use of removable joist	For roads, yards, pavements *and foot traffic*. Especially for sewers, main drainage and duct work	No rocking movement. *Watertight*. Easy *opening* and closing	These covers will withstand any climatic conditions without risk of distortion and are extremely light even when filled with concrete
HARDY & PADMORE, LTD., WORCESTER					
Manhole Covers and Frames	—	—	—	—	—
HARTLEYS (STOKE-ON-TRENT), LTD., STOKE-ON-TRENT					
"Hartleid" Triangular Manhole Cover and Frame	Alternative types for tarmacadam or concrete roads and field type	20 × 20 in. 22 × 22 in. clear opening	For main roads to withstand heaviest traffic	Can be made elongated with double covers to take cables	Guaranteed permanently non-rocking and the cover is hinged and is self-sustaining in the lifted position so that *the cover need not be taken out* for entry or inspection
"Lockleid" *Side Entrance* Gulley Cover	Lid when closed is automatically locked	20 in. wide opening 8 *in. deep*	For main arterial roads	The covers cannot be lifted or *pilfered* without the standard regulation key	—
THE INSULATED CONCRETE PIPE CO., LTD., SHEPPERTON, MIDDLESEX					
Concrete Pipes and Tubes and Junctions ("Linasco")	Corrugated	6 to 24 in. s.s. 27 to 36 in. o.g.	Surface water drainage	—	Exceeds B.S.S. 556, 1945
Porol Concrete Pipes ("Porasco")	For under-drainage	3 to 24 in. with and without impervious inverts	Under-drainage	—	Complies with B.S.S. 1194, 1944
ROBERT JENKINS & CO., LTD., ROTHERHAM					
Welded Fabrications	Steel ground manhole covers	—	—	—	—
JONES, REDFERN & CO., LTD., LONDON, W.8					
V-J Cast Iron Channel	—	6, 8, and 12 in.; 1 ft. lengths	Road gutters	Easy to handle and are connected by corresponding lugs and recesses	—
LEAD WOOL CO., LTD., SNODLAND, KENT					
"Lead Wool"	Pipe-jointing material. Other materials required in connection with pipe-jointing: spun yarn, leaded yarn, lead wire and tape.	—	—	—	—
Testing Appliances for Pipelines. Caulking Tools	Testing plugs and flanges	—	—	—	—
WALTER MACFARLANE & CO., LTD., GLASGOW					
Iron Castings	Drain pipes and fittings. Surface channels. Manhole covers and frames	—	—	—	—
H. R. MANSFIELD, LTD., Near BURTON-ON-TRENT					
Salt Glazed Stoneware Pipes and Fittings	—	2–18 in. diameter	House and general drainage. Electrical conduits. Stop cock water pipes	—	—

PRODUCTS (INCLUDING TRADE NAME IF ANY)	BRIEF DESCRIPTION	STANDARD TYPES AND/OR SIZES	GENERAL USES AND APPLICATIONS	SPECIAL USES AND ADVANTAGES	IMPORTANT INFORMATION CONCERNING PRODUCTS
THE MOORLANDS ENGINEERING CO., LTD., LEEK, STAFFS					
Manhole Covers and Frames	—	—	—	—	—
NORCON, LTD., LONDON, S.W.9					
Concrete Pipes	O.G. and S. & S. joints centrifugally and vertically spun	4–72 in. diameter 3, 6, and 8 ft. lengths	Surface water and foul sewerage	-	All pipes comply with B.S. 556: 1945
Porous Pipes	O.G. joints	4–48 in. diameter	Land drainage	—	All pipes comply with B.S. 1194: 1944
"Norcon" Concrete Manholes with Dovetail Joints	—	36, 42, 48, 54, 60, and 72 in. diam.	Used in lieu of brickwork or in situ concrete	Owing to the dovetail joint, can be constructed in waterlogged ground without risk of infiltration. Can be used for cesspits and when perforated for soakaways	All manholes comply with B.S. 556: 1945
"Norcon" Straightflow Concrete Gullies	—	12–24 in. diameter in depths ranging from 24–54 in. With trapped or straight outlets	For the collection of surface water from carriageways	Cheaper and stronger than glazed stoneware brickwork or in situ concrete	All gullies comply with B.S. 556: 1945
"Norcon" Concrete Combination Gullies	—	18 in. diameter, 30, 36, 42, 48 in. depth trapped or straight outlets	For arterial roads or carriageways where a gully grating in the road surface is undesirable	The combination gully avoids a grating, gives a clear opening of 3 ft. easily accessible from the verge	This gully is supplied complete with cover and frame and reinforced kerb
H. PICKUP, LTD., SCARBOROUGH					
"Lockanlift" Manhole Covers and Frames	Semi-steel covers and frames with special locking and lifting gear	Various type	Highway engineering	Patent 'Lockanlift' gear to facilitate opening and to render cover non-rock and gas tight	—
Gulley Grates and Frames	Cast iron	-	Highways	—	—
SHARP JONES & CO., LTD., PARKSTONE, DORSET					
Salt Glazed Stoneware Pipes and Fittings	Genuine stoneware made from Dorset clay	2–18 in. diameter	House and estate drainage	Made to withstand water, air and acid tests	—
"Rock" Concrete Pipes "Aqualite" Manholes, Gullies, Septic Tanks, etc.	Concrete pipes made by all processes, hume spun rotary spun, mechanically tamped, vibrated	6–96 in. diameter	Main drainage	"Spun" pipes with smooth interior surface for smooth flow	—
THE SOUTH COAST CAST CONCRETE CO., LONDON, S.W.19					
"Southcrete" Concrete Pipes Manholes, Gullies	Precast concrete	To all B.S.S. and trade requirements	For roads and public works	Long life and economy in lieu of iron, steel and timber	—
THE STANTON IRONWORKS, LTD., Near NOTTINGHAM					
Concrete Manholes	Manufactured by spun process	36–72 in. diameter	Storm water and sewage	-	Can be used in waterlogged ground
Concrete Pipes	Manufactured by spun process. Granite aggregate to B.S. 556: 1945	6–72 in. diameter 3, 4, 6 and 8 ft. lengths	Storm water and sewage	—	—
TROLLOPE & COLLS, LTD., LONDON, W.C.2					
"Trocoll" Concrete Pipes	Manufactured with granite or whinstone aggregate and supplied plain or reinforced	Types in accordance with B.S. No. 556. 6–54 in. diameter with S. & S. joints. 15–78 in. diameter with ogee joints, and all sizes of egg-shaped pipes	S. & S. pipes for sewage. Ogee pipes for surface water culverting	-	—
"Trocoll" Concrete Manholes	Manufactured with granite or whinstone aggregate and supplied plain or reinforced	36–72 in. diameter	For use on sewers, from 9–54 in. diameter	Concrete manholes offer many advantages over brickwork, particularly in ease of construction and watertightness	—

Whilst every care has been taken in compiling this information, the omission of any names must not be held as implying any deficiencies in the products of any company concerned.

For full addresses, see Manufacturers' Directory.

SCHEDULE OF PAINTS USED IN ROAD WORK

PRODUCTS (INCLUDING TRADE NAME IF ANY)	BRIEF DESCRIPTION	STANDARD TYPES AND/OR SIZES	GENERAL USES AND APPLICATIONS	SPECIAL USES AND ADVANTAGES	IMPORTANT INFORMATION CONCERNING PRODUCTS
ATLAS PRESERVATIVE COMPANY, LTD., ERITH, KENT					
"ATLAS RUSKILLA"	Iron and steel preservative paint	Available in black, white, aluminium and colours. Packed in ¼, ½ and 1 gallon cans, 5 gallon drums	—	—	—
'ATLAS'	Road marking paints and compositions	—	—	—	—
BITULAC, LTD., NEWCASTLE-ON-TYNE					
"BITULAC" WHITE LINE MARKING PAINT	—	—	For roads, etc	—	—
BRITISH BYE-PRODUCTS, LTD., BARKING					
"CUIRASS"	Bituminous anti-corrosives	1 gallon cans and 5 gallon drums	Preservation of all metal work	Applied cold	—
GOODLASS, WALL & CO., LTD., LONDON, W 1					
"GOODLASS" Q D WHITE & YELLOW LINE ENAMEL	Dries hard in 15 minutes. Tar proof	—	Marking traffic lines and lettering on road surfaces. Applied by brush spray, or lining machine	Resistant to the action of rolling wheels	—
"GOODLASS" Q D WHITE KERB PAINT	Dries with glossy pure white finish tough and resistant to wear and friction	—	For painting over granite kerb-stone. Applied by brush or spray	Solid finish obtained with single coat. Dries hard in approximately 25 mins	
"TRIUMPH" DIRECTION POST PAINT	Dries with an excellent hard wearing finish which gives excellent reflection of headlights at night	Black, green, white and brilliant danger red (for triangles)	For use on all types of wood and metal sign-posts, etc	Weather resistant	-
MATT SURFACE ROADS, LTD., LONDON, S W 1					
"AZTECLINE"	Road line paint	Supplied in white or yellow			
MORRIS & CO. (CHESTER), LTD., CHESTER					
"EGERTON" HARD GLOSS ENAMEL PAINT	A superfine paint for road signs	1 gallon drums	For all descriptions of decorative and protective uses	—	
"SIRROMITE"	A rust inhibitor paint	1 gallon drums	For first coating of metallic surfaces	—	
"SIRROMAX"	Anti corrosive and protective paint	1-gallon drums	For bridge painting and other metallic surfaces	—	—

Whilst every care has been taken in compiling this information, the omission of any names must not be held as implying any deficiencies in the product of any company concerned

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Not all stone, however carefully coated, can provide the surface adhesion which will permanently hold stone and binder together. In the Coated Limestone from our group of quarries you have a reliable binder on a stone which offers not only high compressive strength, but also *a surface to which the coating adheres with utmost tenacity.*

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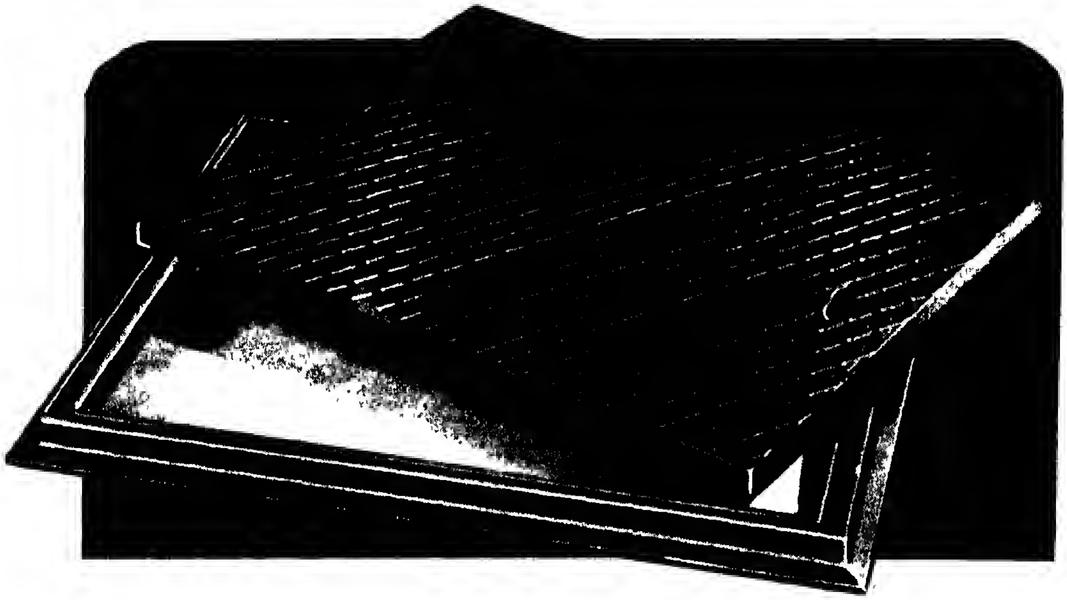

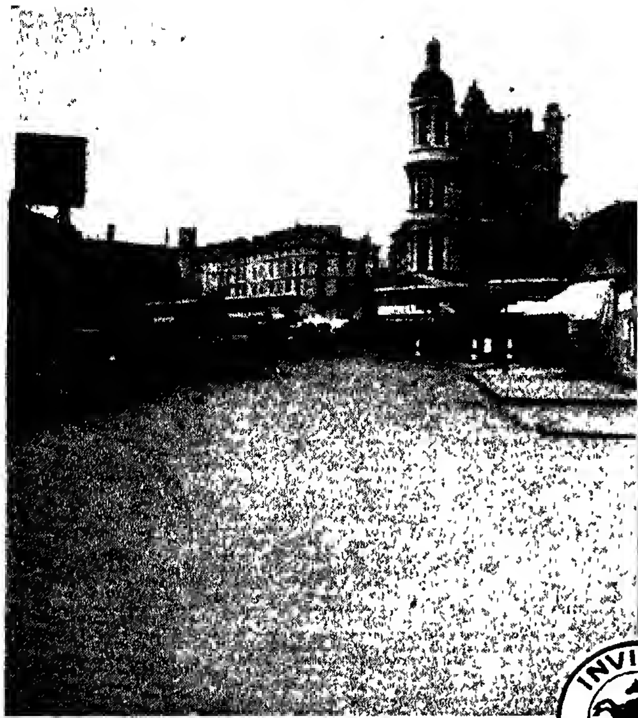

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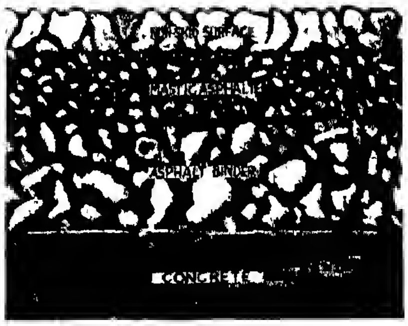

Section of Surface as laid at above

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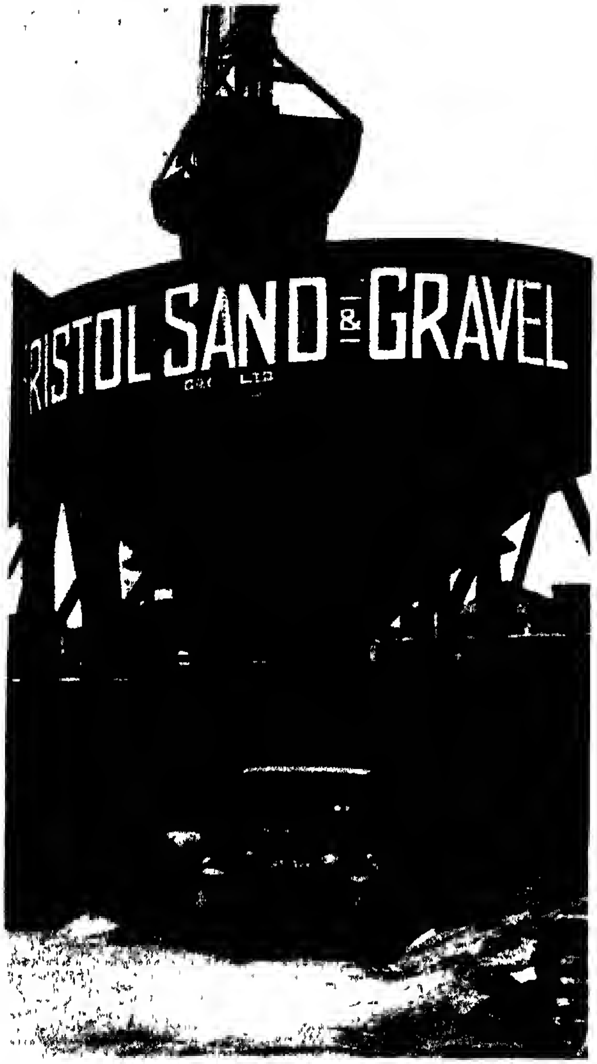

Above *One of the overhead hopper bins that load wagons at the rate of 10 tons per minute.*

Right: *Sand Dredger at work*

Below. *Dredging completed. Ready to start the homeward journey.*

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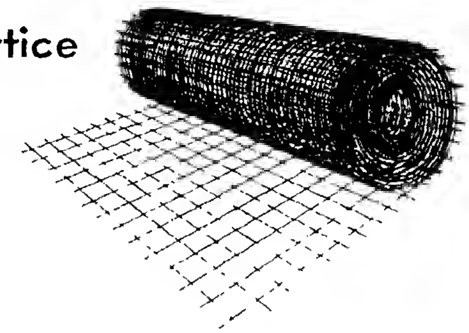
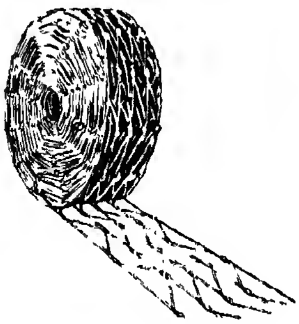


This electrically welded steel-mesh fabric is ideal where a prefabricated reinforcement is required for floors, walls, roofs, roads, etc Supplied in both square and rectangular mesh, in both sheets and rolls to B S.S. 785 and 1221 Economical in first cost and effects tremendous savings on the job Saves 25% in steel and 50% in labour



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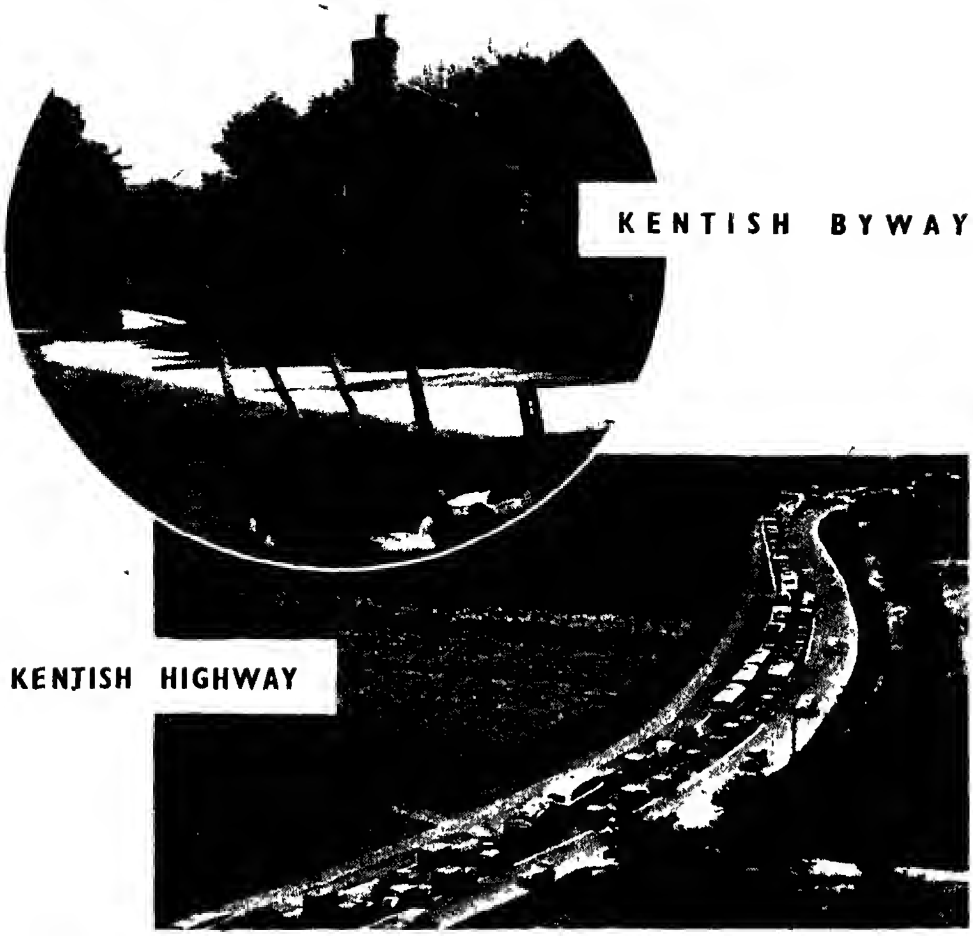
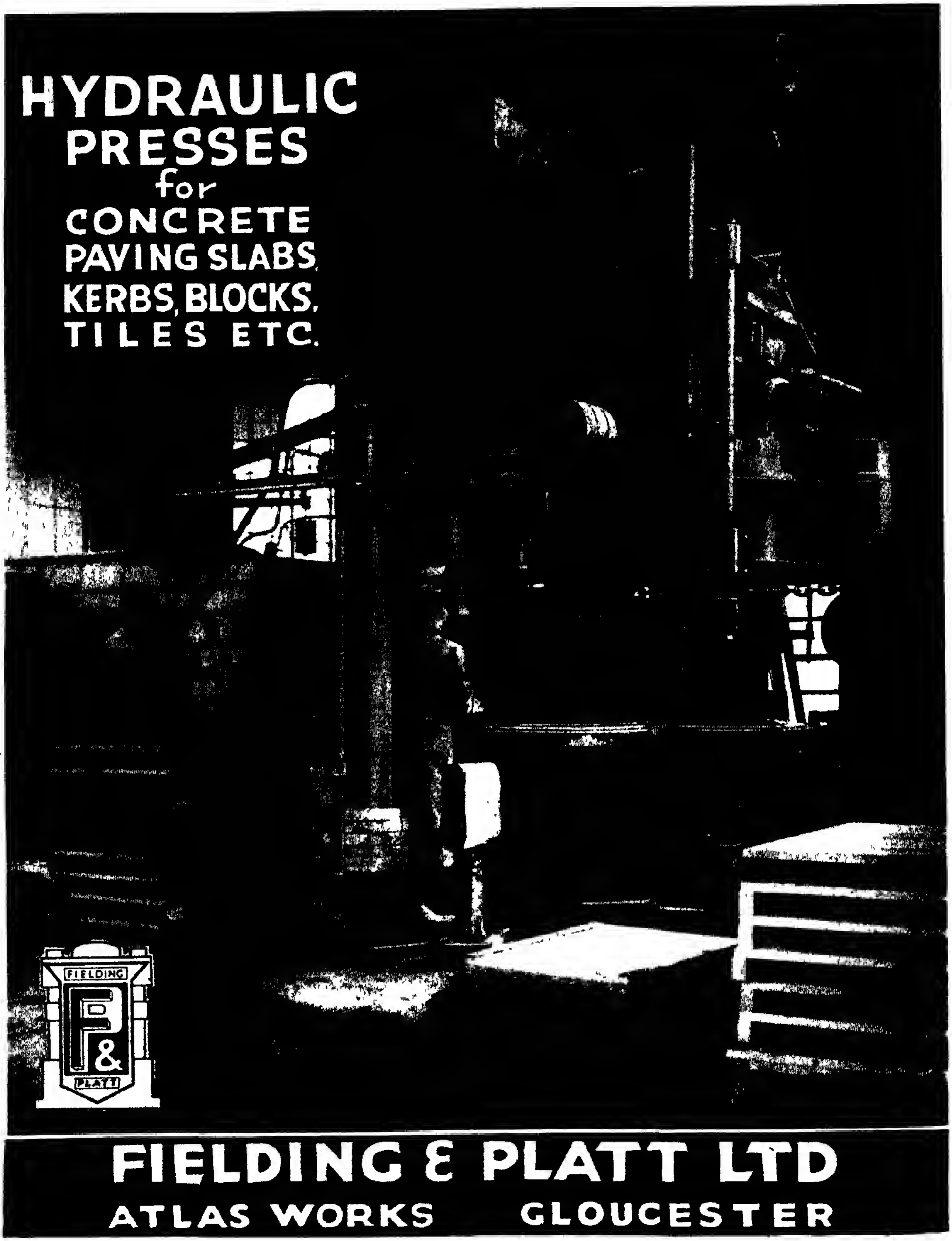

KENTISH BYWAY
KENTISH HIGHWAY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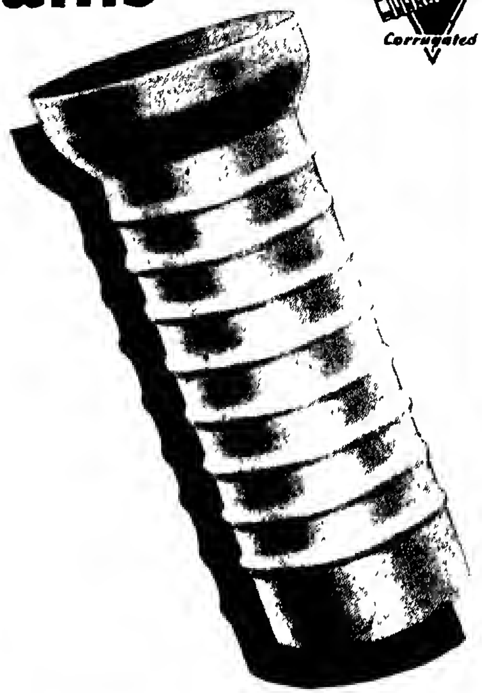
Post-war drainage is a major economic problem, high speed laying is essential ..... with no failures. Linasco Corrugated Concrete Pipes serve these needs ..... their manufacture is a great improvement on all other methods.
The process ..... the vertical spinning method, ensures that each pipe is made of the same unvarying high standard of quality to meet all the requirements of B.S.S. 556.

By specifying Linasco, Surveyors will ensure the use of pipes which will give lasting service.



LINASCO *Corrugated Concrete* PIPES

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The pipe that stands up to B.S.S. No. 1194 of 1944. "Porasco" leads the field in solving drainage problems Highest results in B.S.S porosity tests. 6′ Porasco pipe, for example, passes 8 gallons per minute per lineal foot Exceeds B S S requirements for crushing strength (e.g. 2362 lbs per lineal foot for 6″ pipe). Porasco pipes cost less than Agricultural pipes. Less lines are needed. Porasco centres are placed up to 50 feet apart against usual 12 feet 6 inches No maintenance with "Porasco" pipes No rodding Cannot silt up. Roots cannot enter pipe line.

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COVERS AND FRAMES

Heavy road type 21 × 21 in
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The Main Features of the **"GATIC"** cover are .

Because of the continuous metal-to-metal contact of its vertical, as well as horizontal, seatings with its frame, the cover is immovable under traffic as well as being watertight. Also it is

Easily opened and closed by means of Jack Screw Keys.

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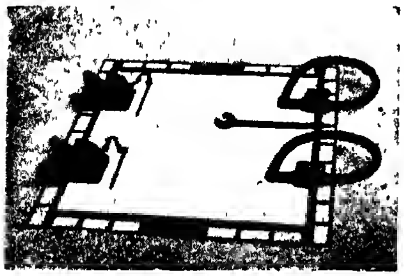
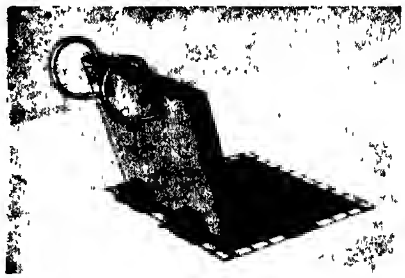
Multiple part covers up to 42 in. span for main roads, 48 in for yards and pavement. Require no cross supports.

For greater spans removable centre joists are provided.

DUCT COVERS AND GRATINGS OF THIS DESIGN ARE AVAILABLE





All **"Elkington-GATIC"** covers and frames can be opened by fitting removable hinges, a moment's operation. Hinges provided with steel safety pins to secure cover in open position. In crowded streets a cover opened this way causes a visible obstruction to oncoming traffic and takes up less room than one opened in normal manner.

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Section Six

MODERN ROAD-MAKING METHODS

ADMINISTRATION, COSTING AND ESTIMATING FOR ROAD CONSTRUCTION

By S GEDDES, E S Dipl. R T C Glasgow

This subject is one of first importance, whether the works are carried out by direct labour under the supervision of the Highway Engineer and his staff, or by a civil engineering firm under contract to the Highway Authority

ADMINISTRATION

In administering works of Road Construction the main objects to be aimed at are

1. Sound workmanship
2. Work constructed at a fast rate of progress
3. Work constructed at low cost.

The fundamentals are as follows:

1 The administrative staff on the site and the foreman, gangers, and leading hands controlling the plant and labour must be thoroughly experienced in the class of work under construction.

2. A "Programme of Work" should be drawn up in order that the various items of work are commenced in the right sequence and at the correct time

3 The plant used on the work should be sound and capable of giving sustained effort with the minimum of time lost in breakdowns

4. The labour should be correctly apportioned to the plant in order to keep it working to capacity with no excess of labour idling

5. The material delivery to the site should be so regulated that both plant and labour are kept constantly employed.

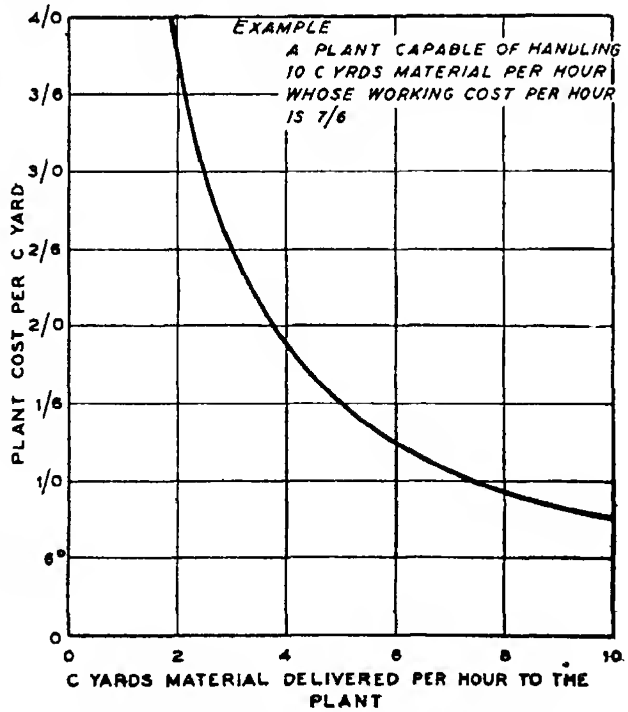

Fig 1.—Graph Showing Increase in Cost per Unit if Plant is not Supplied to Capacity

Having drawn up the programme the following should then be computed

1 The plant required to carry out each component operation and when it must be on the site ready for work.

2 The labour required It is good policy to keep the amount of labour as small as possible, utilizing modern plant The general tendency is for foremen and gangers to "Over labour"

3 The materials required and the daily material delivery should be so regulated that the plant and labour are kept working to capacity The graph shown in Fig 1 illustrates forcibly how plant costs can soar if they are not "fed to capacity".

Progress Charts

The keeping of weekly progress charts is good policy, as from them can be obtained the following

1 How much work has been carried out under the component operations plotted at the end of the current week.
2. The total amount of work done to date.
3 Whether the actual progress is keeping up with the programmed amount (see Fig. 2).

COSTING

Costing the work of construction is generally carried out for the main items of the work, the object of such costing being:

1. To ascertain how the work as a whole is progressing from a financial point of view
2. To ascertain if the individual items of work costed are being carried out in conformity with the estimated costs
3. To obtain data for purposes of future estimating From an estimating point of view, these data are best reduced to terms of plant and labour hours per unit of work since such hour constants are not affected by the variability of plant hire rates and labour rates of pay per hour

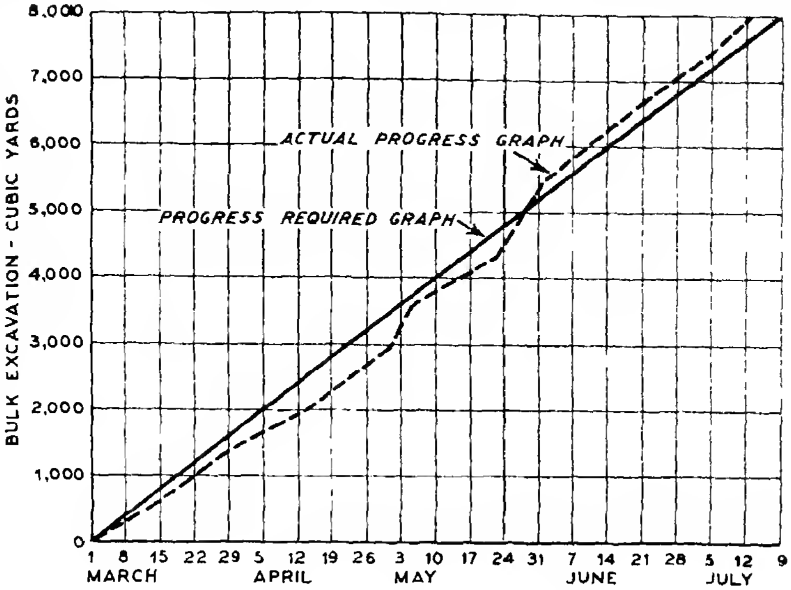

FIG 2 —PROGRESS CHART BULK EXCAVATION

This graph shows typical results The work was behind schedule at first, but was speeded up and eventually finished ahead of schedule

Method of Costing the Works of Construction

Various methods of costing are possible, but in evolving a costing system, its object should be

1 To ensure that it is simple and not unduly costly to operate
2 To produce costs which are as accurate and true as possible

It is usual and preferable to cost the works of construction weekly.

Assuming that a weekly costing system is adopted, the following are entailed

(a) The work performed under the various items of work has to be measured up. This might refer to such work as excavation and haul to tip, lay clinker on sub-base lay concrete in carriage-ways, etc

(b) The plant and labour hours involved have to be carefully allocated to the various items of work

(c) The cost of the materials used per unit of work must be computed or measured.

The Measurement of the Work Done

A typical Works Measurement Sheet is shown in Table I.

Plant and Labour Allocation

The system whereby the plant and labour hours are allocated to the various items of work must be both quick and simple, for this is generally carried out by the foreman or ganger in charge of the construction of the work It will be appreciated that great care and accuracy must be exercised in

TABLE I

TYPICAL WORKS MEASUREMENT SHEET

WORKS MEASUREMENT

Ganger J Smith — *Contract* Gednol Road Construction — *Week Ending* 13th July, 1946

Item	*Description*	*Unit*	*Weeks Quantity*	*Previous Quantity*	*Quantity to Date*
1	Excavate over site to formation level and haul to tip not exceeding 440 yards haul	Cu Yds.	700	1100	1800
2	Trim Formation	Sq Yds	1420	2130	3550
3	Supply and lay 3 in consolidated clinker	Sq Yds	1400	2100	3500
4	Supply and lay 6 in. reinforced concrete all as specified	Sq. Yds	1320	2000	3320

TABLE II
TYPICAL ALLOCATION SHEET FOR PLANT AND LABOUR

PLANT AND LABOUR HOUR WEEKLY ALLOCATION SHEET

Ganger. J Smith — *Week Ending* 13th July, 1946

Contract Gednol Road Construction

Item	Description	Labour Hours			Plant Hours			
		Bricklayer	Pipelayer and Jointer	Labourer	⅜ Cu Yd Mechanical Excavator Machine No 3	5 Ton Tipping Lorries Lorry Nos 5, 8, 9	14/10 Concrete Mixer Machine No 7	2 Ton Petrol Roller Machine No 2
1	Excavate and haul to tip	—	—	48	48	144		
2	Trim formation	—	—	96	-	--	--	
3	Lay and roll 3 in consolidated clinker	-	—	144	—		--	48
4	Lay 6 in reinforced concrete	—	—	336	—	96	48	—

allocating these hours to the various items of work, if the costs produced are to be accurate

To this end, it is advisable to have a *daily* allocation sheet for plant and labour, summarized at the end of the week on a *weekly* plant and labour allocation sheet

It should be impressed on the foreman or ganger that he must allocate all time to the items of work and not to irrelevant items, as the tendency is to allocate time to such items as unloading pipes, etc , thinking that by so doing they are keeping down the cost of the actual pipelaying The unloading, is, of course, part and parcel of the pipelaying and should be allocated under such

This can be obviated if the various items of work against which time has to be allocated, are filled in on the allocation sheet by the engineer, as this ensures the time being allocated to the relevant items

A typical allocation sheet is shown in Table II

The daily allocation sheet is similar to Table II except that it is headed "Plant and Labour Hour Daily Allocation Sheet"

In order to illustrate costing systems two simple methods of costing which have been proved by experience are shown

In method No. 1, the cost of the material per unit, if any, is calculated and a small percentage added to it, to allow for waste.

In method No. 2, the actual quantity of material is measured In method No 1 the production of the costs is cheap, quick, involves no measurements of materials, and has proved quite satisfactory.

METHOD NO 1.

This method is carried out in the following manner.

1. The weekly allocated plant and labour hours are monied out under the various items of work
2. The cost of the material per unit is worked out and a percentage added to it to allow for waste
3. The work is measured up weekly, and the weekly quantity of work done under the various items of work is calculated, as is the progressive quantity to date

Having entered these data on the cost sheet the costs are produced thus

(*a*) The plant cost and the labour cost per unit of work are found by dividing the plant and labour weekly cost by the corresponding quantity of work done for the week under that item

(*b*) The "All in" weekly cost per unit, where materials are present, is found by adding the calculated material cost per unit to the plant and labour or labour only cost per unit as the case may be

(*c*) The progressive costs are found in a similar manner, the progressive costs being divided by the progressive amount of work done under the various items of work

Example 1 illustrates this method

Example 1

Calculate the weekly plant, labour and material cost of concreting a road, the following being the plant and labour allocated cost and the total concrete placed in the work for the week in question:

1. *Quantity of concrete placed in the work = 200 cu yds.*

2. *The material cost of the concrete as calculated=28s. per cu. yd*
3. *The plant cost as allocated for the week=£40.*
4. *The labour cost as allocated for the week=£25.*

The costs per cu yd are worked out on the following lines

Plant cost per cu yd $= £\frac{40}{200} = 4/-$ per cu yd.

Labour cost per cu yd $= £\frac{25}{200} = 2/6$ per cu. yd

The total plant labour and material cost per cu yd. is therefore

Plant cost	=	4/-	per cu yd
Labour cost	=	2/6	per cu yd
Material cost	=	28/-	per cu yd
Total cost	=	34/6	per cu yd

Assuming the estimated cost was 36/- per cu yd the saving per cu. yd is 1/6 or put in another way, the actual cost is 4 16 per cent lower than the estimated cost

METHOD 2

So far as the plant and labour cost per unit is concerned, Method No 2 is carried out in a manner similar to that of Method No 1 The material cost, however, is arrived at from the actual measurement of the material used in the work, this being done thus

Assuming that the amount of materials used per week in concreting a road is required, the material is measured and noted on a weekly material allocation sheet. In connection with this it will be noted that

1 Any concreting material lying on the site at the end of each week has to be measured and the measurement recorded
2 The material delivered to the site during the week has to be measured and such measurements recorded

The typical material allocation sheet shown in Table III indicates how the data are recorded and how, from this, the material used for the week is calculated

Example 2 illustrates Method No 2

Example 2

Calculate the weekly plant labour and material cost of concreting a road, the following being the particulars relating to the work.

1 *"All-in-Ballast" used during week=200 cu yds Cost, delivered to site=12/- per cu yd*
2 *Cement used during week=34 tons Cost, delivered to site, including sacks=65/- per ton.*
3. *Total amount of concrete placed, measured in situ =160 cu yds*
4. *Allocated weekly plant cost=£32*
5 *Allocated weekly labour cost=£20.*

TABLE III

TYPICAL MATERIAL ALLOCATION SHEET

MATERIAL WEEKLY ALLOCATION SHEET

Ganger. J. Smith — *Contract* Gednol Road Construction — *Week Ending* 13th July, 1946

Date	*All in Ballast—Cu Yds*			*Cement—Tons*		
	On Site at end of previous week	*Delivered Site during week*	*Material remaining on Site at end of working week*	*On site at end of previous week*	*Delivered Site during the week*	*Material remaining on Site at end of working week*
7th July	10	20	—	2	10	—
8th July	—	40	—	—	10	—
10th July	—	40	—	—	10	—
11th July	—	40	—	—	10	—
12th July	—	40	—	—	—	—
13th July	—	40	30	—	—	8
Total	10	220	30	2	40	8

All in Ballast used for Week=(10 plus 220) − 30=200 Cu Yds

Cement used for Week=(2 plus 40) − 8=34 Tons.

TABLE IV—WEEKLY COST SHEET

COST SHEET NO 13

Ganger J. Smith. *Contract*· Gednol Road Construction *Week Ending* 13th July, 1946

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Item No.	*Description*	*Unit*	*Week's quantity*	*Previous quantity*	*Total quantity to date*	*Weekly plant cost as allocated*	*Weekly labour cost as allocated*	*Progressive plant cost as allocated*	*Progressive labour cost as allocated*	*Material cost per unit*	*Week's plant cost per unit*	*Week's labour cost per unit*	*Progressive plant cost per unit*	*Progressive labour cost per unit*	*Week's Total Plant Labour and Material Cost per unit*	*Progressive total plant, labour and material cost per unit*	*Estimated cost per unit*	*Total actual cost of work to date*	*Total value of work done on estimated rates*
						£ s d	£ s d	£ s d	£ s d									£ s d	£ s. d
1	Excavate over site and haul to tip at 440 yards	cu yd.	1000	2000	3000	112 6 8	16 13 4	325 0 0	50 0 0	nil	2/3	4*d*	2/2	4*d*	2/7	2/6	3/-	375 0 0	450 0 0
2	Concrete in carriage-way 6 in. thick Etc , etc.	cu. yd	100	200	300	25 16 6	9 3 4	67 10 0	30 0 0	25 -	5/2	1/10	4/6	2/	32/-	31/6	36/-	472 10 0	540 0 0
																	TOTAL	847 10 0	990 0 0

Notes.—1. The excavation was carried out by a ⅜ cubic yard mechanical excavator fitted with skimmer equipment and transported in 5-ton lorries fitted with mechanical tipping gear

2. Concreting was carried out using a 14/10 concrete mixer the concrete being transported in dumpers.

The costs per cu yd. are worked out on the following lines

$$\text{Plant cost} = £\frac{32}{160} = 4/\text{- per cu yd}$$

$$\text{Labour cost} = £\frac{20}{160} = 2/6 \text{ per cu yd.}$$

The material cost is

	£	s	d
200 cu yds of "All-in Ballast" at 12/- per cu yd.	120	0	0
34 tons of cement at 65/- per ton	110	10	0
Total	230	10	0

This represents the cost of 160 cu. yds. of concrete as measured in the work

The material cost of 1 cu yd is therefore

$$\frac{£230\ 10\ 0}{160} = 28/10.$$

The total plant labour and material cost per cu yd is therefore

Plant cost	4/-
Labour cost	2/6
Material cost	28/10
Total cost	35/4 per cu yd

Assuming, as was done in Example 1 that the estimated cost was 36/- per cu yd , the saving per cu. yd is 8d , or put in another way, the actual cost is 1·85 per cent lower than the estimated cost

The Weekly Cost Sheet

The Unit costs are recorded on cost sheets and these should show not only the weekly but also the progressive costs, as the latter represent the fair average costs appertaining to the work. It is such costs which are an important asset when estimating.

In the typical cost sheet shown in Table IV, all the data which it is desirable to record are included, the columns being numbered to simplify their explanation The method of working out the cost is as follows, the numbers representing the number of the columns.

	Column
Weekly plant cost per unit	7—4=12
Progressive plant cost per unit	9—6=14
Weekly labour cost per unit	8—4=13
Progressive labour cost per unit	10—6=15
Weekly plant, labour and material cost per unit	11+12+13=16
Progressive plant, labour and material cost per unit	11+14+15=17
Total actual cost of the work constructed to date	6 × 17=19
Total estimated cost of the work constructed to date	6 × 18=20

Note—The percentage the actual cost of the work is above or below the estimated cost is given by subtracting the actual progressive cost (col. 19) from the total estimated cost (col 20) or vice versa, and dividing this by the actual progressive cost.

ESTIMATING FOR ROAD WORK

The estimation of the cost of road construction work is influenced by such factors as

1. The nature of the site and class of ground
2. The weather conditions likely to prevail, i e. a summer job or a winter one
3. Water may or may not be available on the site
4. Temporary roads may be required in order to get access to the site

Estimates are produced from recorded cost data of similar works carried out, these costs being best recorded, for purposes of estimating, in terms of plant and labour hours per unit of work since such data is unaffected by any fluctuations in plant or labour rates The "building up" of a price from first principles backed by experience also enters into estimating, but to produce a sound and accurate estimate, the main items comprising the major parts of the work should be based on actual average costs of similar works

Tables of Estimating Data used for Estimating Purposes

In order to illustrate how estimates are "built up", Tables V to XXVIII give representative estimating data for various component operations in connection with the construction and reconstruction of roads. The data are shown as plant and labour hour constants, so are in no way affected by variation in plant hire rates or labour rates. The material required per unit of work is also stated, so that the estimator has available all the necessary data.

Tables of Multipliers

Tables of multipliers are shown for use with the plant and labour hours shown in the tables of estimating data, their function being to supply much information in concise form. Multipliers

are also used in connection with carrying out work in different classes of ground, the main data shown referring for example to sand, and the multipliers covering other grounds, such as clay, gravel, chalk, etc. As an example of this, the data shown in Table VIII, page 294, are for excavating in firm sand, multipliers being shown for other classes of ground.

Hour Constants shown in Estimating Tables

The plant and labour hours are those taken for the unit of work shown which, when extended by the monetary rates prevailing, represent the cost of producing the unit of work in question.

The method of using the tables is as follows

Plant Cost per unit of Work

The plant cost per unit of work is obtained by multiplying the plant hour constants shown in the tables by the hire rate or working cost of the plant per hour This hire rate or working cost per hour must be wholly inclusive of

1. The machine hire rate per hour allowing for depreciation, repairs and renewals.
2. The wages of the operator per hour
3. The cost of the fuel oil and grease consumed per hour.
4. The cost of insurance and licence costs, if any

Labour Cost per Unit of Work

The labour cost per unit of work is obtained by multiplying the labour hour constants shown in the tables by the prevailing labour rate of pay per hour.

Material Cost per Unit of Work

The material cost per unit is obtained by calculating the amount of material required in the unit of work, allowing a reasonable percentage addition to allow for waste.

The tables of estimating data shown refer to:

1. Excavation
2. Road foundation work
3. Construction of roads in concrete.
4. Tarmacadam and bituminous macadam surfacing to roads.
5. Surface dressing to roads.
6. Granite sett roads.
7. Wood block paving.

In connection with these data the following notes are important.

1. The result arrived at from the data shown represents the estimated cost of the work only, i e the plant labour and material cost, and is not a rate to tender
2. To allow for "overheads" and "profit" a percentage addition of sufficient amount must be added to the estimated cost
3. In using the data shown, care must be taken to ensure that no part or parts of the operations involved in carrying out the work are omitted

   e.g. concreting is shown under more than one table The data shown in Table XIII, page 296 are for "mixing and placing only" Transporting the concrete is dealt with in subsequent tables. The same applies to excavation, this being shown as "excavate and load only" under Table V, the transporting to tip being built up from data shown in other tables

   In such cases more than one table has to be used in order to "build up" the estimate of the cost
4. The cost of such items as watching and lighting, traffic control, supply of water, haulage of plant and temporary roads is not allowed for, these are the subject of additional cost should they be required on the work.

EXCAVATION

The data shown for estimating purposes in connection with excavation for roadwork is for excavation carried out by mechanical plant of two kinds viz.

1. Mechanical excavators of the skimmer type
2. Tractors and scrapers.

Excavation by Mechanical Excavators of the Skimmer Type

In estimating the cost of excavation carried out by the above type of plant, three items have to be noted in order that the cost may be estimated, viz:

1. The time taken by the plant to dig and load 1 cu. yd. of solid material into the vehicle used to transport it.
2. The time the vehicle stands while 1 cu. yd. is loaded into it, and, knowing how many cu. yds. of solid material it can hold, the time it stands whilst being loaded.
3. The time the vehicle takes to travel to tip, offload and return for the next load.

TABLE V

EXCAVATION BY MECHANICAL EXCAVATORS FITTED WITH SKIMMER EQUIPMENT

Notes —1 The Hours shown are those taken to Dig and Load One Cubic Yard They also represent the Hours the Transporting Plant Stands while One Cubic Yard of material is loaded into it
2. For the Cubic Yards of material (Solid) hauled per Load, using various types and sizes of vehicles, see Table VI
3 For the Time taken by various types of Transporting Plant to haul to tip at various lengths of haul, see page 294

Bucket Capacity of Machine in Cu Yds	*Nature of Ground and Plant Hours Excavating and Loading per Cubic Yard* Note —*The Hours shown also represent the Hours the Transporting Plant stands while One Cubic Yard is loaded into it*				
	Firm Sand	*Loamy Soil, Soft or Sandy Clay or Marl*	*Gravel*	*Stiff Clay*	*Soft Chalk*
¼	0·083	0·120	0·130	0·141	0·166
⅜	0·050	0·070	0·075	0·085	0·100
½	0·037	0·053	0·056	0·063	0·074
⅝	0·025	0·035	0·038	0·043	0·050
¾	0·022	0·030	0·033	0·038	0·044
⅞	0·019	0·027	0·029	0·033	0·038
1	0·017	0·024	0·026	0·030	0·034

In order that the cost of excavation may be estimated for various combinations and sizes of excavating and transporting plant, tables are shown for the following.

(*a*) The time taken by various sizes of excavating plant to dig and load 1 cu. yd of solid material (Table V.)

Note.—The plant hours shown in this table also represent the hours the vehicle stands while 1 cu yd is loaded into it

(*b*) The cubic yards of solid excavation hauled per load using various types and capacities of haulage plant (Table VI)

(*c*) The time taken by the vehicles to haul the load to tip, offload and return for the next load (Table VII, page 294)

Note —The length of haul shown in the table is the distance from the point of loading to the point of offloading.

In order to illustrate the use of these tables, the following examples are shown

Example 1

Estimate the cost of excavating soft clay, using a ½ cu yd mechanical excavator, fitted with skimmer scoop equipment, 5-ton lorries fitted with mechanical tipping gear being used to transport the excavated material to tip The length of haul (one way) is ½ mile. One labourer is in attendance on the excavator, while three are employed on the tip, a total of 4 men

TABLE VI

THE CUBIC YARDS OF SOLID MATERIAL HAULED PER LOAD BY VARIOUS TYPES OF TRANSPORTING PLANT

Notes —1 In transporting by dumpers or wagons the bulkage of the material should be taken into account Such vehicles are rated on a volume basis, their struck measured capacity being stated The vehicles, however, have a "Heaped Capacity" the load being heaped in the vehicle In the table the cubic yards hauled per cubic yard of "Struck Measured Capacity" allow for normal heaping of the loads and the bulkage of the various materials, thus a 2 cubic yard dumper hauls 2 × 0·80 = 1·60 cubic yards of stiff clay (solid) per load
2 In hauling excavated materials by lorry, the weight of load carried should not exceed that which the vehicle is designed to carry

Nature of Material hauled	*Weight of the material in the solid cu yds per ton*	*Haulage by lorries cu yds of material (solid) hauled per load*						*The cu yds of solid material hauled by dumpers or in wagons per cu yd. of "Struck measured capacity"*
		1-*ton lorry*	2-*ton lorry*	3-*ton lorry*	4-*ton lorry*	5-*ton lorry*	6-*ton lorry*	
Chalk	0·58	0·58	1·16	1·74	2·32	2·90	3·48	0·70
Soft or Sandy Clay	0·75	0·75	1·50	2·25	3·00	3·75	4·50	0·85
Stiff Clay	0·69	0·69	1·38	2·07	2·76	3·45	4·14	0·80
Gravel	0·75	0·75	1·50	2·25	3·00	3·75	4·50	1·14
Loam	0·87	0·87	1·74	2·61	3·48	4·35	5·22	0·92
Marl	0·75	0·75	1·50	2·25	3·00	3·75	4·50	0·98
Sand	0·87	0·87	1·74	2·61	3·48	4·35	5·22	1·09
Soil . .	0·83	0·83	1·66	2·49	3·32	4·15	4·98	0·90

TABLE VII

THE TRAVELLING TIME TAKEN PER LOAD BY VARIOUS TYPES OF TRANSPORTING PLANT TO HAUL TO TIP, OFFLOAD AND RETURN FOR THE NEXT LOAD

Notes—1 The hours shown are the average hours taken per round trip including the time taken to offload They do *not* allow for the time the vehicle stands while it is being loaded See Table V.

2 For the cubic yards of material (solid) hauled per load See Table VI.

Length of haul from point of loading to point of offloading	*Type of haulage plant used and plant hours per load*			
	Lorries fitted with mechanical tipping gear	*Dumpers*	*Tractor drawn wagons*	*Locomotive and Decauville wagons on 2 ft. gauge track*
100 Yards	0 08	0 10	0 12	0 19
220 Yards	0 10	0 12	0 18	0 27
440 Yards	0 13	0 17	0 29	0 33
660 Yards	0 15	0 21	0 37	0 38
880 Yards	0 17	0 25	0 43	0 45
1 Mile	0 28	0 38	0 62	0 66
2 Miles	0 46	—	—	—
3 Miles	0 63	—	—	—

TABLE VIII

EXCAVATION BY TRACTORS AND SCRAPERS

Note—The hours shown are for excavating firm sand For other classes of ground use multipliers as shown in Table IX

Type of tractor	*Drawbar Horse power*	*Rated Capacity of Scraper*		*Length of haul (one way) in lin yards and plant hours per cubic yard*				
		heaped cu yds	*struck cu yds*	100	200	300	400	500
D4	35	4 0	3 5	0 031	0 038	0 053	0 060	0 066
D6	55	7 5	6 0	0 019	0 026	0 034	0 040	0 045
D7	80	9 5	7 2	0 016	0 022	0 028	0 032	0 037
D7	80	11 0	8 2	0 014	0 019	0 025	0 028	0 030
D8	113	14 0	11 0	0 012	0 015	0 019	0 022	0 026
D8	113	15 0	12 1	0 011	0 014	0 018	0 021	0 024
D8	113	16 0	12 5	0·010	0 013	0 017	0 019	0 021

For the purpose of this example the following rates are assumed.

Hire rate of ½ cu. yd. mechanical excavator including driver, fuel and oil = 12/6 per hour

Hire rate of 5-ton lorries including driver, fuel and oil = 8/- per hour

Labour Rate = 2/- per hour

FROM TABLE V, PAGE 293.

A ½ cu yd excavator with skimmer equipment digs and loads 1 cu. yd of soft clay in 00 53 hours

FROM TABLE VI, PAGE 293.

Cubic yards of soft clay hauled in a 5-ton lorry per load = 3·75 cu. yds.

FROM TABLE VII.

The travelling time taken by the lorry to haul to tip ¼ mile away, offload and return for the next load = 0 13 hours per load.

The estimated cost of excavating and hauling to tip then is.

Excavating per cubic yard.

Mechanical excavator digging and loading 0·053 hours at 12/6 = 7 95 pence per cu. yd.

Lorry standing whilst being loaded = 3 75 cu yds at 0 053 hours per cu yd = 0 20 hours

Lorry travelling only to tip, offload and return for the next load = 0 13 hours

∴ Total lorry hours per load = 0 33 hours

∴ Lorry hours per cu yd. $= \frac{0\ 33}{3\ 75} = 0{\cdot}09$ hours.

∴ Transporting cost per cu yd = 0·09 hours at 8/- per hour = 8 64 pence per cu yd

Labour hours per cubic yard.

4 No. labourers at 0 053 hours each = 0 212 hours at 2/- per hour = 5 09 pence per cu yd

∴ The total estimated cost of the excavation is

Plant excavating cost	7·95 pence per cu. yd.
Transporting cost	8 64 pence per cu. yd.
Labour cost	5 09 pence per cu. yd.

∴ Total estimated cost = 21·68 pence per cu. yd.

Note.—*Any cost incurred in hauling the plant is not allowed for in the estimated cost shown.*

Example 2

Calculate the cost of excavating soft clay, using a D6 tractor and 6 cu yd. scraper, the average length of haul (one way) being 400 yds For purposes of this example it will be assumed that the hire rate of the tractor and scraper including driver, fuel and oil, is 30/- per hour

FROM TABLE VIII.

Hours taken by a D6 tractor and scraper to excavate firm sand to a 400 yd haul = 0 04 hours per cu. yd

From Table IX, the multiplier for soft clay is 1 33

plant hours per cu yd = 1 33 × 0 04 hours per cu yd

= 0 053 hours per cu yd

∴ The estimated cost of excavating = 0 053 hours at 30/- = 19 08 pence per cu yd

Note.—*Any cost incurred in hauling the plant is not allowed for in the estimated cost shown*

TABLE IX

TABLE OF MULTIPLIERS FOR USE WITH TABLE VIII FOR GROUND OTHER THAN FIRM SAND

Nature of Ground	*Plant Hour Multiplier*
Firm Sand	1 00
Firm Soil	1 25
Gravel	1 25
Loamy Soil, Soft or Sandy Clay and Marl	1·33
Stiff Clay	1·50
Soft Chalk	3 00

ROAD FOUNDATIONS

Road foundations consist of such materials as brick or concrete hardcore, stone pitching or concrete *in situ* It is usual to lay consolidated clinker on the formation prior to laying the foundation material proper

In constructing foundations of clinker, hardcore, etc, the compression of the material under the weight of the roller used for consolidation has to be allowed for in assessing the amount of material required to produce one square yard to the required consolidated thickness

In Tables X and XI the amount of material required to produce one square yard to the consolidated thicknesses shown is stated, these amounts allowing for consolidation The percentage increase to allow for this consolidation is also stated The percentages shown strike a fair average, having been computed from practical experience of normal foundation works.

Examples are shown illustrating the "build up" of the estimated cost of such work

Example 1

Calculate the cost of supplying, laying and rolling 3 in of consolidated clinker laid on the formation of a new road, the following being the prevailing rates

Hire rate of 2-ton petrol roller inclusive of driver, fuel and oil — 5/- per hour

Labour rate = 2/- per hour

Material cost of clinker delivered site = 6/- per cu yd

Referring to Table X, the cost per square yard is given by

2-ton petrol roller	= 0 018 hours at 5/- =	1 08 pence
Labour	= 0 07 hours at 2/- =	1 68 pence
Material cost of clinker	= 0 111 cu yds. at 6/- =	8 00 pence
		10 76 pence

The total estimated cost of 3 in consolidated clinker = 10 76 pence per sq yd

TABLE X

LAY AND ROLL CLINKER PER SQUARE YARD

Note —The data shown are based on clinker weighing 50 lb per cubic foot, and an allowance of 33⅓ per cent is made for consolidation

Consolidated thickness of clinker laid in inches	*Lay and roll clinker per square yard*			
	Clinker required per sq yd		*Roller hours*	*Labourer hours*
	cubic yards	*tons*		
2 in.	0 074	0 046	0 016	0 06
3 in.	0 111	0 069	0 018	0·07
4 in	0 148	0 092	0·020	0 08
5 in	0 185	0 115	0 022	0 09
6 in.	0 222	0·140	0 024	0 10

TABLE XI

LAY AND ROLL BRICK OR CONCRETE HARDCORE PER SQUARE YARD

Note —The data shown are based on brick hardcore weighing 70 lb and concrete hardcore weighing 80 lb per cubic foot in the loose, and an allowance of 33⅓ per cent is made for consolidation

If the hardcore is handpacked, use a labour multiplier of 2·50 with the labour hours shown

Consolidated thickness of brick or concrete hardcore laid in inches	*Lay and roll brick or concrete hardcore per square yard*					
	Hardcore required per square yard					
	Brick		*Concrete*		*Roller hours*	*Labourer hours*
	cubic yards	*tons*	*cubic yards*	*tons*		
4 in	0·148	0·123	0·148	0·142	0·025	0·150
5 in	0·185	0·157	0·185	0·178	0·026	0·156
6 in	0·222	0·189	0·222	0·213	0·027	0·162
7 in	0·260	0·221	0·260	0·250	0·028	0·168
8 in	0·297	0·252	0·297	0·285	0·029	0·174
9 in	0·333	0·283	0·333	0·320	0·030	0·180
12 in	0·444	0·378	0·444	0·426	0·033	0·189

TABLE XII

CUBIC YARDS OF AGGREGATE AND SAND, AND TONS OF CEMENT REQUIRED TO MAKE 1 CUBIC YARD OF CONCRETE OF VARIOUS MIXES

Note —The data shown are based on the aggregate voids being 40 per cent

Mix			*Aggregate cu yds*	*Sand cu yds*	*Cement tons*
Aggregate	*Sand*	*Cement*			
2	1	1	0·76	0·38	0·42
3	1	1	0·90	0·30	0·32
3	1½	1	0·80	0·40	0·29
3½	1¾	1	0·82	0·41	0·26
4	2	1	0·84	0·42	0·22
5	2	1	0·90	0·36	0·20
5	2½	1	0·88	0·44	0·19
5	3	1	0·84	0·50	0·18
6	2½	1	0·94	0·39	0·17
6	3	1	0·90	0·45	0·16
7	2½	1	0·96	0·34	0·15
7	3	1	0·92	0·40	0·14
7	4	1	0·88	0·50	0·13
8	3	1	0·96	0·36	0·13
8	4	1	0·90	0·45	0·12
9	4	1	0·90	0·40	0·11
10	5	1	0·84	0·42	0·10
12	6	1	0·80	0·40	0·07

TABLE XIII

CONCRETING ROADS USING 10/7, 14/10 AND 20/14 CONCRETE MIXING PLANT OF THE DRUM AND HOPPER TYPE, THE MIXING PLANT BEING LOADED BY HAND

Notes —1 The hours shown are for mixing, placing and tamping the concrete only, the tamping being carried out by hand

2 For transporting the concrete see Table XV.

3. For laying reinforcement, curing, bullnosing edges, etc See Table XVII, page 299

Description	*Type of mixing plant and plant and labour hours mixing, placing and tamping per cubic yard*					
	10/7		14/10		20/14	
	Plant hours	*Labour hours*	*Plant hours*	*Labour hours*	*Plant hours*	*Labour hours*
Concreting roads *Note* —The hours shown are for mixing, placing, and tamping only, see notes above	0·25	2·00	0·20	1·80	0·14	1·54

Example 2

Calculate the cost of supplying, laying and rolling brick hardcore laid to a consolidated thickness of 9 in., the following being the prevailing plant and labour rates:

Hire rate of 10 ton roller including driver and fuel = 10/- per hour

Labour rate = 2/- per hour

Material cost of brick hardcore delivered site = 7/6 per cu. yd.

Referring to Table XI, the cost per square yard is given by.

Roller	0·030 hours at 10/- =	3 60 pence
Labour	0 180 hours at 2/- =	4 33 pence
Material cost of hardcore	0 333 cu yd 7/6 =	29 97 pence
		37 90 pence

∴ The total estimated cost of 9 in. consolidated hardcore = 37 90 pence per sq yd

CONCRETE ROADS

For purposes of illustration, the concreting of roads is here dealt with, using drum and hopper type mixing plant of the 10/7, 14/10 and 20/14 type, these being popularly used for this class of work Separate tables are shown for the following operations

1 Materials required to make 1 cu yd of concrete of various mixes (Table XII)
2 Mixing and placing the concrete, the mixing plant being loaded by hand or mechanically (Tables XIII and XIV)
3 The cubic yards of concrete hauled per load, using various types and sizes of transporting plant (Table XV)
4 The time taken by various types of transporting plant to transport a load of concrete from the mixing plant to the point of off-loading, offload and return to the mixing plant for the next load (Table XVI, page 298)

TABLE XV

CUBIC YARDS OF CONCRETE HAULED PER LOAD USING VARIOUS SIZED LORRIES AND DUMPERS ETC

Note —The data shown are based on concrete weighing 140 lb per cubic foot

Type of plant used to transport the concrete	*Cubic yards of concrete hauled per load or per wagon*
1 Ton Lorry	0 60
2 Ton Lorry	1 20
3 Ton Lorry	1 80
4 Ton Lorry	2 40
5 Ton Lorry	3 00
6 Ton Lorry	3 60
2 Cu Yd Dumper	1 60
3 Cu Yd Dumper	2 40
¾ Cu Yd Decauville Wagons	0 60
1 Cu Yd Decauville Wagons	0 80

The data shown allow for mixing, transporting, placing and tamping the concrete by hand but does not allow for fixing road forms and expansion joints, bullnosing the edges, laying reinforcement or curing Data for these operations are shown in Table XVII, page 299

MIXING AND PLACING ONLY (Tables XIII and XIV)

In these tables are shown the plant and labour hours taken to mix, place and tamp one cubic yard of concrete The hours shown extended by the prevailing plant and labour rates give the estimated cost of these operations per cubic yard of concrete

TRANSPORTING THE CONCRETE

The time during which a vehicle is engaged in transporting a load of concrete is the sum of:

TABLE XIV

CONCRETING ROADS AS TABLE XIII, BUT MIXING PLANT LOADED BY MECHANICAL LOADING PLANT

Note —The loading plant hours shown refer to those of a dragline, shovel or grab

Description	*Type of mixing plant and mixing and loading plant and labour hours mixing, placing and tamping per cubic yard*								
	10/7			14/10			20/14		
	Mixing Plant hours	*Loading Plant hours*	*Labour hours*	*Mixing Plant hours*	*Loading Plant hours*	*Labour hours*	*Mixing Plant hours*	*Loading Plant hours*	*Labour hours*
Concreting roads *Note* —The hours shown are for mixing, placing and tamping only See notes above	0 21	0 21	1 47	0 17	0 17	1 36	0 12	0 12	1·20

1. The standing time while being loaded
2. The time taken to travel from the mixing plant to the point of offloading, offload and return to the mixing plant for the next load.

The standing time during loading is the product of the mixing plant hours per cubic yard of concrete and the cubic yards of concrete hauled per load

The vehicle hours taken to transport the concrete per cubic yard are the sum of the vehicle standing time plus the travelling time, divided by the cubic yards of concrete hauled per load

In transporting concrete by locomotive and wagons the hours shown in Table XVI are per set of wagons By correctly assessing the number of wagons per set, in conjunction with the output of the mixing plant and the length of haul, one set of wagons is being filled while another is being hauled

The examples shown do not include the cost of water, it being assumed that this has been allowed for elsewhere in the estimate, nor has any cost incurred in connection with the haulage of plant been allowed for

Example 1

Calculate the cost of mixing, transporting, placing and tamping concrete in a road, the length of haul from the mixing plant to the point of offloading being one mile The concrete has to be 4 2 1 by volume mix, using 1½ to ½ in. shingle, washed sand and cement The mixing plant used is a 14/10 revolving drum concrete mixer, fitted with a power loading skip, the mixer being loaded by hand The concrete is transported in 5-ton tipping lorries, fitted with mechanical tipping gear

For purposes of this example the following rates are assumed:

Hire rate of mixing plant inclusive of driver, fuel and oil = 6/- per hour
Hire rate of 5-ton lorries, inclusive of driver, fuel and oil = 8/- per hour
Labour rate = 2/- per hour
Cost of 1½ to ½ in shingle delivered site = 12/- per cu yd
Cost of washed sand = 14/- per cu yd
Cost of cement inclusive of the charge for sacks = 65/- per ton

MIXING AND PLACING THE CONCRETE PER CUBIC YARD

From Table XIII, page 296, using a 14/10 concrete mixer, the cost of mixing and placing the concrete only, is given by

14/10 concrete mixing plant	0 20 hours at 6/-	= 14 40 pence
Labour	1 80 hours at 2/-	= 43 20 pence
		57 60

∴ The estimated cost of mixing and placing the concrete = 57 60 pence per cu yd

TRANSPORTING THE CONCRETE PER CUBIC YARD

From Table XIII, the mixing plant hours per cubic yard = 0 20 hours

TABLE XVI

TRAVELLING TIME TAKEN BY VARIOUS TYPES OF TRANSPORTING PLANT TO TRANSPORT A LOAD OF CONCRETE FROM THE MIXING PLANT TO THE POINT WHERE OFFLOADED, OFFLOAD AND RETURN TO THE MIXING PLANT FOR THE NEXT LOAD

Notes —1 The hours shown are those taken by the transporting plant in travelling only They *do not* allow for the time the plant stands while it is being loaded
2 The time the plant stands while it is being loaded is the mixing plant hours per cubic yard (as shown in Tables XIII and XIV) multiplied by the cubic yards of concrete hauled per load
3 The total transporting hours per *cubic yard* is the sum of the transporting plant standing time plus the travelling time per load divided by the cubic yards hauled per load
4 In the case of transport by lorries the data shown are based on lorries fitted with mechanical tipping gear

Type of transporting plant used	*Length of haul from mixing plant to point of offloading and travelling time only taken by transporting plant to haul concrete from mixing plant to point of offloading, offload and return to mixing plant for next load in hours per load*							
	100 *yards*	220 *yards*	440 *yards*	660 *yards*	880 *yards*	1 *mile*	1½ *miles*	2 *miles*
Lorries Hours per load	0.08	0 10	0 13	0 15	0 17	0 28	0 37	0 46
Dumpers Hours per load	0 10	0 12	0 17	0 21	0 25	0·38	—	—
Decauville wagons and locomotive on 2-ft gauge track: Hours per set of wagons	0·19	0·27	0·33	0 38	0 45	0·66	—	—

TABLE XVII

SUNDRY WORKS TO CONCRETE ROADS

Description	*Unit*	*Labour hours*
Bullnose edges with bullnose trowel per edge	Lin Ft	0.04
Curing – Lay and remove hessian	Sq Yds	0.08
Curing — Lay and remove sand	Sq Yds	0.20
Curing — Lay and remove waterproof paper	Sq Yds	0.05
Curing by canvas covered frames	Sq Yds	0.12
Fix expansion jointing material 6 in deep	Lin Ft	0.08
Fix expansion jointing material 9 in deep	Lin Ft	0.12
Fix steel road forms	Sq Ft	0.16
Fix timber road forms –straight	Sq Ft	0.24
Fix timber road forms – to quick sweep	Sq Ft	0.40
Lay sheet reinforcement weighing 3 lb sq yd	Sq Yd	0.03
Lay sheet reinforcement weighing 4 lb sq yd	Sq Yd	0.04
Lay sheet reinforcement weighing 5 lb sq yd	Sq Yd	0.05
Lay sheet reinforcement weighing 6 lb sq yd	Sq Yd	0.06
Lay sheet reinforcement weighing 7 lb sq yd	Sq Yd	0.07
Lay waterproof paper	Sq Yd	0.02
Apply silicate of soda per dressing (0.07 galls per sq yd of 4 of water to 1 of silicate)	Sq Yd	0.04

TABLE XVIII

SURFACING ROADS WITH TARRED SLAG PER SQUARE YARD

Notes 1 The data shown are based on broken slag weighing 87 lb per cubic foot

2 The data shown are for tarred slag laid in areas in excess of 500 square yards For areas less than this use the table of multipliers shown on page 300 (Table XXI)

Consolidated thickness of tarred slag laid in inches	*Lay and roll tarred slag per square yard* — *Tarred slag required per square yard* — *Bottom coat* — *Thickness in inches*	*Bottom coat* — *Tons*	*Top coat* — *Thickness in inches*	*Top coat* — *Tons*	*Roller hours*	*Labour hours*
2	1½	0.066	½	0.022	0.015	0.10
2½	1½	0.066	1	0.044	0.018	0.12
2½	1¾	0.077	¾	0.033	0.018	0.12
3	2	0.088	1	0.044	0.021	0.14
3	2¼	0.100	¾	0.033	0.021	0.14
3½	2½	0.110	1	0.044	0.024	0.16
3½	2¾	0.121	¾	0.033	0.024	0.16
4	3	0.132	1	0.044	0.027	0.18
4	3¼	0.143	¾	0.033	0.027	0.18

These Data are also applicable to tarmacadum and bituminous macadam surfacing

From Table XV, page 297 a 5-ton lorry hauls 3.00 cu yds of concrete per load.

∴ Lorry standing time whilst being loaded
=3.00 cu yds × 0.20 hours
=0.60 hours per load.

From Table XVI, the travelling time only taken by the lorry to haul from the mixing plant to a point a mile away, offload and return to the mixing plant is 0.28 hours per load

The total lorry hours per load of 3.00 cubic yards of concrete therefore is 0·88 hours, or 0.29 hours per cubic yard.

∴. Estimated cost of transporting the concrete per cu. yd.=0·29 hours at 8/-=27.84 pence per cu yd

MATERIAL COST OF CONCRETE PER CUBIC YARD

Referring to Table XII, page 296, the material cost of 4 2 1 concrete per cubic yard is given by 1½ to ½ in

Shingle	0.84 cu yd at 12/-	=120.96 pence
Washed sand	0.42 cu yd. at 14/-	= 70·56 pence
Cement	0·22 tons at 65/-	=171.60 pence
		=363·12
Add for waste say 2½ per cent.		= 9.08

∴. The estimated material cost=372·20 pence per cu yd.

TABLE XIX

SURFACING ROADS WITH TARRED LIMESTONE PER SQUARE YARD

Notes :—1 The data shown are based on solid limestone weighing 155 lb per cubic foot.
2 The data shown are for tarred limestone laid in areas in excess of 500 square yards For areas less than this use the multipliers shown in Table XXI

Consolidated thickness of torred limestone laid in inches	*Lay and roll tarred limestone per square yard*					
	Tarred limestone required per square yard				*Roller hours*	*Labour hours*
	Bottom coat		*Top coat*			
	Thickness in inches	*Tons*	*Thickness in inches*	*Tons*		
2	1½	0·064	½	0·021	0·015	0·10
2½	1½	0·064	1	0·042	0·018	0·12
2½	1¾	0·074	¾	0·032	0·018	0·12
3	2	0·084	1	0·042	0·021	0·14
3	2¼	0·094	¾	0·032	0·021	0·14
3½	2½	0·105	1	0·042	0·024	0·16
3½	2¾	0·115	¾	0·032	0·024	0·16
4	3	0·126	1	0·042	0·027	0·18
4	3¼	0·136	¾	0·032	0·027	0·18

TABLE XX

SURFACING ROADS WITH TARRED GRANITE PER SQUARE YARD

Notes :—1 The data shown are based on solid granite weighing 166 lb per cubic foot
2 The data shown are for tarred granite laid in areas in excess of 500 square yards For areas less than this use the multipliers shown in Table XXI

Consolidated thickness of tarred granite laid in inches	*Lay and roll tarred granite per square yard*					
	Tarred granite required per square yard				*Roller hours*	*Labour hours*
	Bottom coat		*Top coat*			
	Thickness in inches	*Tons*	*Thickness in inches*	*Tons*		
2	1½	0·072	½	0·024	0·015	0·10
2½	1½	0·072	1	0·048	0·018	0·12
2½	1¾	0·084	¾	0·036	0·018	0·12
3	2	0·096	1	0·048	0·021	0·14
3	2¼	0·108	¾	0·036	0·021	0·14
3½	2½	0·120	1	0·048	0·024	0·16
3½	2¾	0·132	¾	0·036	0·024	0·16
4	3	0·144	1	0·048	0·027	0·18
4	3¼	0·156	¾	0·036	0·027	0·18

The Data shown in Tables XIX and XX are also applicable to tarmacadam and bituminous macadam surfacing.

TABLE XXI

TABLE OF MULTIPLIERS FOR USE WITH TABLES XVIII–XX. TARMACADAM AND BITUMINOUS MACADAM WHERE THE AREAS SURFACED ARE LESS THAN 500 SQUARE YARDS

Area of Surfacing laid in Square Yards	*Plant and Labour Hour Multipliers*
0 to 20	2·50
over 20 to 50	2·10
over 50 to 100	1·80
over 100 to 200	1·60
over 200 to 300	1·40
over 300 to 400	1·20
over 400 to 500	1·10
over 500	1·00

TABLE XXII

SQUARE YARDS COVERED BY VARIOUS SIZES OF CHIPPINGS OR GRAVEL PER CUBIC YARD AND PER TON

Size of chippings or gravel	*Square yards covered*				
	Per cubic yard	*Per ton*			
		Sand	*Granite*	*Limestone*	*Gravel*
Sand	220	190	—	—	—
⅛	180	—	178	198	183
¼	160	—	156	173	160
⅜	140	—	133	148	137
½	110	—	102	114	105
¾	90	—	82	94	85

The total estimated cost of the concrete mixed, transported, placed in the work and tamped by hand per cubic yard is:

Mixing and placing	= 57 60 pence
Transporting	= 27 84 pence
Material cost	=372 20 pence
	457 64 pence

Example 2

Calculate the plant, labour and material cost per cubic yard of mixing, transporting and placing concrete in a new roadway, the length of haul from the mixing plant to where deposited in the work being one mile. The concrete mixer used is a 20/14 mixer mechanically loaded by dragline and the transport used to transport the concrete is Decauville wagons, hauled by a locomotive on 2-ft gauge track, one set being filled while the other is being hauled

For purposes of this example the following rates are assumed.

Hire rate of 20/14 mixer including driver, fuel and oil=7/6 per hour

Hire rate of dragline including driver, fuel and oil =9/- per hour

Hire rate of locomotive wagons and rails=8/6 per hour

Labour rate=2/- per hour

Material cost of the concrete per cubic yard is as shown in example No 1, 372 20 pence per cu. yd

Referring to Table XVI, page 298, the time taken by a locomotive to haul to tip one mile distant from the mixing plant is 0 66 hours per trip.

Referring to Table XIV, page 297, a 20/14 mixer loaded by dragline produces one cubic yard in 0·12 hour

∴ In 0 66 hours it produces $\frac{0\ 66}{0\ 12}$ or 5 50 cu yds of concrete.

∴ Sufficient wagons per set must be used to haul 5 50 cubic yards of concrete per trip Say 8 No 3/4 cubic yard wagons.

TABLE XXIII

LABOUR HOURS TAKEN TO SWEEP DOWN SURFACES AND APPLY CHIPPINGS OR GRAVEL OF VARIOUS SIZES

Size of Chippings or Gravel used	*Sweep down surfaces and apply chippings or gravel. Labour Hours per Square Yard*
Sand	0 018
⅛	0 020
¼	0·022
⅜	0·024
½	0 026
¾	0·030

MIXING, PLACING AND TAMPING THE CONCRETE PER CUBIC YARD

From Table XIV, page 297, the plant and labour cost of mixing and placing only per cubic yard is

Concrete mixer hours	=0 12	at 7/6	=10 80 pence
Dragline hours	=0 12	at 9/-	=12 96 pence
Labour hours	=1 20	at 2/-	=28 80 pence
			52 56 pence

∴ The estimated cost of mixing and placing only =52 56 pence per cu yd

TRANSPORTING THE CONCRETE PER CUBIC YARD

Locomotive hours hauling 5 50 cu yds =0 66 hours per trip

∴ Locomotive hours hauling 1 00 cu yd $=\frac{0\ 66}{5\ 50}$ =0 12

The estimated cost of transporting the concrete =0 12 hours at 8/6=12 24 pence

The total estimated cost of the concrete is therefore

Mixing and placing	= 52 56 pence
Transporting	= 12 24 pence
Material cost	=372 20 pence
Total	=437 00 pence

Note —In connection with the above the cost of hauling the plant, locomotive, rails, wagons, etc., and the laying and removal of the track are not allowed for and must be taken into account

TARMACADAM AND BITUMINOUS MACADAM SURFACING

The above surfacing is carried out with aggregates suitable for road surfacing work coated with bituminous tar, tar or tar compounds, the aggregates most commonly used being broken granite, limestone, gravel or slag

Under the weight of the roller the surfacing material compresses, and this must be allowed for in assessing the amount of material required to produce one square yard of finished surfacing to the consolidated depths specified. In Tables XVIII to XXI, the amount of material required per square yard allowing for such consolidation is shown and the data are for laying and spreading by hand.

Table XXI gives multipliers for use in conjunction with the data shown in the estimating tables,

where the area to be laid is less than 500 square yards

Example (material, tarred slag)

Calculate the cost of supplying, laying and rolling tarred slag in two coat work on the prepared foundation of a new road, the area being in excess of 500 square yards

The finished consolidated thickness is to be 3 in., the bottom coat being 2¼ in and the top ¾ in thick The material is delivered on site in mechanical tipping lorries and the following are the prevailing plant, labour and material rates

Hire rate of roller inclusive of driver, fuel, etc = 10/- per hour
Labour rate = 2/- per hour
Material cost of tarred slag for bottom coat delivered site = 37/- per ton
Material cost of tarred slag for top coat delivered site = 40/- per ton

From Table XVIII, page 299, the cost per square yard is estimated as follows

Roller 0 021 hour at 10/- = 2 52 pence
Labour 0 14 hour at 2/- = 3 37 pence
Material cost of bottom coat 0 10 tons at 37/- = 44 40 pence
Material cost of top coat 0 033 tons at 40/- = 15 84 pence
Total = 66 13 pence

The total estimated cost of 3 in consolidated surfacing=66 13 pence per sq yd

Table XXIV

SURFACE DRESSING WITH BITUMEN, TAR, TAR COMPOUNDS OR COLD BITUMINOUS EMULSION, USING PORTABLE BOILERS OR TANKS PER SQUARE YARD

Notes -1 The data shown are for portable plant of approximately 150 to 250 gallons capacity, operated by hand
2 For heating, allow 0 003 cwt of fuel per gallon of tar
3 The data shown are for applying the dressing and rolling only For sweeping down and applying chippings or gravel, see Tables XXII and XXIII

Rate of application square yards per gallon	*Applying dressing and rolling per square yard*				
	Gallons required per square yard	*Boiler hours*	*Roller and driver hours*	*Lorry and driver hours*	*Labour hours applying dressing*
3	0 333	0 0092	0 0092	0 0092	0 028
4	0 250	0 0070	0 0070	0 0070	0 021
5	0 200	0 0055	0 0055	0 0055	0 017
6	0 166	0 0046	0 0046	0 0046	0 014
7	0 143	0 0040	0 0040	0 0040	0 012

Table XXV

SURFACE DRESSING WITH BITUMEN, TAR, TAR COMPOUNDS OR COLD BITUMINOUS EMULSION, USING LARGE MOBILE PRESSURE SPRAYING PLANT, PER SQUARE YARD

Note -1 The data shown are for applying the dressing and rolling only For sweeping down and applying chippings or gravel see Tables XXII and XXIII

Rate of application square yards per gallon	*Applying dressing and rolling per square yard*				
	Gallons required per square yard	*Pressure spraying plant hours*	*Roller and driver hours*	*Lorry and driver hours*	*Labour hours in attendance on plant applying dressing only*
3	0 333	0 0028	0 0028	0·0028	0 0056
4	0 250	0 0021	0 0021	0 0021	0 0042
5	0 200	0 0017	0 0017	0 0017	0 0034
6	0 166	0 0014	0 0014	0 0014	0 0028
7	0 143	0 0012	0 0012	0 0012	0 0024

Note -The lorry hours shown are for one lorry If the work entails the use of two or more lorries the lorry hours shown should be multiplied by the number of lorries which it is assessed will be required

SURFACE DRESSING ROADS WITH BITUMEN, TAR, TAR COMPOUNDS AND COLD BITUMINOUS EMULSION

The rate of application is important, as this determines to a large extent the durability of the surface If too much is applied, "bleeding" results, and if insufficient, premature failure of the dressing.

The chippings used for blinding the surface after treatment may be either rock chippings, or gravel, the latter requiring an application of approximately 20 per cent more than the former. The rate of application depends on the state of the surface which has to be treated

Surface dressing is carried out with boilers where hot material is used, or with tanks where cold emulsion is applied For small areas portable plant of 150 to 250 gallons capacity is generally used, while large areas are more economically carried out with mobile pressure spraying plant.

For purposes of estimating the cost of this class of work the following tables are shown:

Table XXII, page 300

This shows the square yards covered by grit or chippings of various sizes per cubic yard or per ton.

TABLE XXVI

SURFACING ROADS IN GRANITE SETTS

Note —The data shown are for areas in excess of 50 square yards For areas less than this use Table XXVII

Description	*Unit*	*Material required*	*Pavior hours per unit*	*Labour hours per unit*
Remove old setts	Sq Yd	—	—	0 40
Clean old setts for re-use	Sq Yd			1 25
Lay cement mortar 1 in thick	Sq Yd	1 in cement mortar	0 25	0 25
Lay cement mortar 1¼ in thick	Sq Yd	1¼ in cement mortar	0 30	0 30
Lay cement mortar 1½ in thick	Sq Yd	1½ in cement mortar	0 35	0 35
Relay old setts and grout in	Sq Yd	1 20 cu ft cement mortar	0 80	0 80
Lay new 4 4 in setts approximately 8 in long and grout in	Sq Yd	0 80 cu ft cement mortar	0 50	0 50
Lay new 4×5 in setts approximately 8 in long and grout in	Sq Yd	1 00 cu ft cement mortar	0 60	0 60
Raking cutting	Lin Ft		0 24	0 24
Circular cutting	Lin Ft		0 36	0 36

TABLE XXVII

MULTIPLIERS FOR USE WITH TABLE XXVI FOR AREAS LESS THAN 50 SQUARE YARDS

Area in Square Yards	*Pavior and Labour Hour Multipliers*
0 to 2	2 00
over 2 to 5	1 80
over 5 to 10	1 60
over 10 to 25	1 40
over 25 to 50	1 20
over 50	1 00

TABLE XXIX

MULTIPLIERS FOR USE WITH TABLE XXVIII, FOR AREAS LESS THAN 50 SQUARE YARDS

Area in Square Yards	*Pavior and Labour Hour Multipliers*
0 to 2	2 00
over 2 to 5	1 80
over 5 to 10	1 60
over 10 to 25	1 40
over 25 to 50	1 20
over 50	1 00

TABLE XXVIII

SURFACING ROADS IN WOOD BLOCK PAVING

Note 1 For fuel for heating mastic allow 0 25 cwt coke per cwt of mastic
2 The data shown are for areas in excess of 50 square yards For areas less than this use Table XXIX

Description	*Unit*	*Material required*	*Pavior hours per unit*	*Labour hours per unit*
Remove old block paving	Sq Yd	—	--	0 25
Clean old block paving for re-use	Sq Yd	—		0 40
Lay cement mortar 1 in thick	Sq Yd	1 in of cement mortar	0 25	0 25
Lay cement mortar 1¼ in thick	Sq Yd	1¼ in of cement mortar	0 30	0 30
Lay cement mortar 1½ in thick	Sq Yd	1½ in. of cement mortar	0 35	0 35
Relay old blocks and grout in	Sq Yd	0 25 cwt mastic 0 10 cwt cement and 0 25 cubic feet of sand	0 70	0 70
Lay 9 3 4 in deep new wood block paving grouted in mastic	Sq Yd.*	45 No blocks 0 30 cwt mastic	0 40	0 40
Raking cutting	Lin Ft	—	0 10	0 10
Circular cutting	Lin Ft	–	0 15	0 15

TABLE XXIII, PAGE 301

This gives the labour hours taken per square yard in sweeping down the surfaces to be treated prior to application, and applying the chippings

TABLE XXIV, PAGE 302

Table showing the gallons of surface dressing material required per square yard and the plant and labour hours taken to apply the material per square yard, using portable boilers

TABLE XXV, PAGE 302

Showing the gallons of surface dressing material required per square yard and the plant and labour hours taken to apply the material per square yard, using large mobile pressure spraying plant.

Example

Calculate the cost of tar dressing a road using a 200-gallon portable tar boiler, the rate of application being 5 square yards per gallon and the blinding used $\frac{3}{8}$ in. gravel. A lorry is assumed to be used in attendance

For the purpose of this example the following rates are assumed:

Hire rate of portable boiler including fuel, 5/- per hour
Hire rate of roller including driver, fuel and oil, 7/6 per hour
Hire rate of lorry, including driver, fuel and oil, 7/6 per hour
Labour rate, 2/- per hour
Material cost of tar delivered site, 10d per gallon
Material cost of $\frac{3}{8}$ in gravel, 13/- per ton

FROM TABLE XXII, PAGE 300

The covering capacity of $\frac{3}{8}$ in. gravel is 137 square yards per ton.

∴ The cost of gravel per square yard

$$=\frac{13/-}{13\cdot75} = 1\cdot14 \text{ pence per sq yd.}$$

FROM TABLE XXIII, PAGE 301

The labour hours taken to sweep down and grit $=0\cdot024$ hours per sq yd

∴ Cost of sweeping and applying grit $=0\cdot024$ hours at 2/- $=0\cdot57$ pence per sq. yd.

FROM TABLE XXIV, PAGE 302

Hire of boiler	$=0\cdot0055$ hours at 5/-	$=0\cdot33$ pence
Hire of roller	$=0\cdot0055$ hours at 7/6	$=0\cdot50$ pence
Hire of lorry	$=0\cdot0055$ hours at 7/6	$=0\cdot50$ pence
Labour hours applying tar	$=0\cdot017$ hours at 2/-	$=0\cdot40$ pence
Cost of tar	$=0\cdot20$ gallons at 10d.	$=2\cdot00$ pence

The total cost of dressing per square yard is therefore:

Cost of $\frac{3}{8}$ in. gravel	$=1\cdot14$ pence
Sweep down and apply $\frac{3}{8}$ in. gravel	$=0\cdot57$ pence
Hire of boiler	$=0\cdot33$ pence
Hire of roller	$=0\cdot50$ pence
Hire of lorry	$=0\cdot50$ pence
Cost of tar	$=2\cdot00$ pence
Labour applying tar	$=0\cdot40$ pence
	$5\cdot44$ pence

∴ Total estimated cost $=5\cdot44$ pence per sq yd

ROADS IN GRANITE SETT PAVING

This class of road is associated with heavy traffic, such as quay sides, fishmarkets, depot yards, etc It consists of granite setts, superimposed on a hard foundation, concrete commonly being used for this when the setts are grouted in

ROADS IN WOOD BLOCK PAVING

These roads consist of wood blocks, superimposed on a concrete foundation and then grouted in The data shown are for laying the blocks and grouting them together with other relevant data

The estimator should note that this type of road is generally associated with traffic and cities and that traffic control and watching and lighting of an extensive nature may be necessary

The cost of this might be considerable and is *not* allowed for in the data shown

The object of both the Highway Engineer and the Civil Engineering Contractor in carrying out works of road construction is the same, viz to achieve soundly constructed roads at *low cost*

In an article of this length it is not possible to delve deeply into a subject with so vast a field but it is hoped that sufficient has been included to illustrate that the success of the work from all points of view centres round accurate estimation of the cost of the work and its sound administration.

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For roads and slabs, the ground surface is prepared as for traditional concrete, the large aggregate is tipped directly into place from lorries and raked down to the required thickness.

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For full addresses, see Manufacturers' Directory

THE HOLLOWAY-RADIAL SCHEME FOR CONCRETE CARRIAGEWAY INTERSECTIONS

By S. A HOLLOWAY, Assoc. M.Inst H.E

THE object of this scheme is to simplify the construction at the intersections of Concrete Carriageways. The two main advantages are that there are no angles of the concrete which are less than 90 degrees and that the construction can be carried forward with the minimum of delay and trouble

The *Radial Form* as shown in Fig 1 is the continuation of the line from the centre of the radius of the circular kerb to the point where the right angle of the kerb lines of roads "X" and "Y" is found.

The *Parallel Form* also shown is the line of the channel of road "X" produced at point "B" and continued through point "C" to point B 1 where the other Radial Form is fixed.

On the plan, the Radial Forms are 6 ft. 4 in in length, which is determined by the length of the radius of the circular kerb, in this case 15 ft A minimum length of 6 ft. is desirable for the Radial form. The length of the Parallel Form is 24 ft, i.e. the width of Road "Y".

The plan is based upon that of a site which is flat, and the centre of the scheme on Road "X" at point "D" has had to be raised 2 in. above the normal rise of the crown, making 6 in. at that point, and "boned" from either direction of Road "X" and of Road "Y" at a point 90 ft. back. If there is a longitudinal fall on Road "X", this rise may be minimized or dispensed with altogether

The vertical section through A—A.1. gives the general rise of levels of this site. The end of the Radial Form at Point "B" is raised 4 in. above the level at the channel at point "A" The level of the parallel form at point "C" is raised one inch above point "B", and the level at point "D" is raised a further inch above point "B".

All the forms are to be sited and fixed in advance of the work, and the construction will be carried on with the normal work, of which the concrete sections Nos 1, 2 and 3 are exceptions.

When section No. 1 is to be constructed the 12 ft tamper of the normal work will be used for the first 6 ft. of progress, and from this point to point "B" another tamper of 17 ft in length is used The first 12 ft of this tamper from the channel is shaped as for the normal tamper, the remaining 5 ft being of a flat trajectory from the 12 ft. to the 17 ft length This tamper will cover the area and line of progress. When the tamper has reached the maximum at point "A", the crown end will coincide with the centre line form, and this position for progress should be continued allowing the channel end of the tamper to overlap into the Transition Bay area. On reaching point "B" the camber will have become nearly flat, and another 12 ft. tamper will be used which will be nearly flat, having a maximum rise of ½ an inch at the centre from the chord of the arc, this being necessary to offset the tendency of a concaved surface. This will be continued to point "C" and will have completed the concrete section No 1.

The section No 2 will be constructed in the reverse order of operations. The normal concrete sections of Road "Y" having been constructed, it remains for No 3, the Transition Bay of 20 ft. length, to be laid to complete the scheme. This is done by tamping longitudinally, after the edges of all the sections concerned have matured sufficiently The centre expansion joint as produced from Road "Y" may be omitted if desired. The fine lines show the line of tamping for the various sections. This scheme can be adapted to any other type of concrete carriageway intersection.

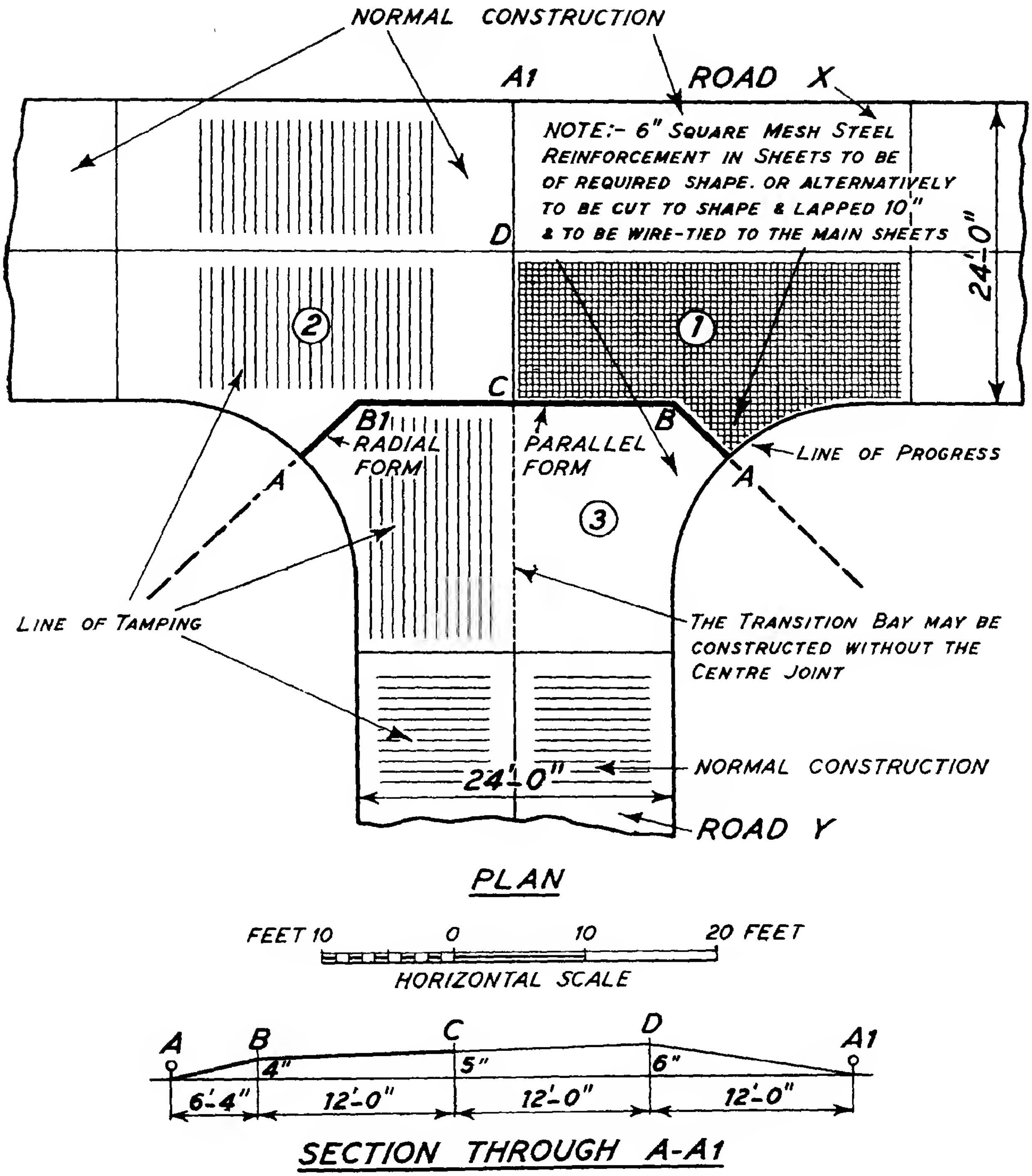


Fig. 1 —Typical Intersection of Concrete Carriageways, Showing the Use of Radial and Parallel Forms

Section Seven

EQUIPMENT FOR ROAD CONSTRUCTION

ROAD-MAKING PLANT AND MACHINERY

By W. P ROBINSON, C B E, B Sc, M Inst C E

THE contribution of mechanical plant of all kinds towards greater speed in execution combined with greater efficiency is a subject of vital importance in road construction and repair Experience gained during the late war will be of great value in the highway programme which is envisaged in the near future.

DIGGING, MOVING AND COMPACTING EARTH

On small works, the usual methods of moving excavated materials include
(*a*) Wheelbarrows, (*b*) Horse-drawn carts and wagons, (*c*) Lorries, (*d*) Decauville railway and tip wagons

WHEELBARROWS

These are usually of the single-wheel type, the wheel being made of wood shod with iron If the wheel is shod with rubber less effort is required to wheel and mount obstructions The capacity of the barrow is normally 2 to 2½ cu ft Assuming that a man can wheel a loaded barrow at the rate of 60 yards per minute or 2 miles per hour and the distance the earth has to be moved is 60 yards which is about the limit for economy, the round trip will take 2 minutes, plus an additional ½ minute for unloading, adjusting barrow runs, if any, and rests. The rate of output, assuming barrows are filled by excavators, will be 2 cu ft in 2½ minutes or 14 cu yds in an 8 hour day. If wages are 12/- per day the cost of wheeling alone is 10d. per cu. yd This form of transport for 60 yards haul is not economical either in time or money.

Some barrows have two wheels, i.e. barrows designed for concrete in which the container can be tipped forward They have the advantage of relieving the operator's arms of some of the weight, but there is sometimes difficulty in mounting obstructions. The capacity may be increased to 3 or 4 cu. ft. but no advantage over a single wheel barrow is gained by the use of this type if two men are required to push it. Wooden wheel barrows would be improved by lining with sheet steel to give cleaner discharge.

HORSE-DRAWN CARTS

Two-wheel carts used for excavation should have end-tip bodies, should preferably be steel lined and have wheels shod with rubber Assuming the rate of travel at 3 miles per hour, the capacity 1 cu. yd, the distance of haul 60 yards, and the cost of hire 30/- per day, a round trip will occupy 1½ minutes travelling and ½ minute unloading, etc. The rate of output will be 1 cu yd in 2 minutes, 30 cu yds per hour or 240 cu yds per 8 hour day, at a cost of 1½d per cu yd This does not allow any time for filling Adding 2 minutes for filling by excavator the round trip occupies 4 minutes, giving an output of 15 cu yds per hour and a cost of 3d per cu yd, a very different figure from the wheelbarrow method

Four-wheeled wagons are seldom used because of lack of tipping devices During the Great War the Canadians introduced a four-wheeled wagon with a hinged floor, similar to the power-driven Euclid wagon, which could be opened by the driver to discharge the contents (about 2 cu yds) onto the ground whilst travelling

LORRIES

Provided that the ground conditions are good, the lorries fitted with mechanically-tipped bodies and the time occupied in loading and unloading is kept to a minimum, this is a convenient method of transport in the absence of scrapers, dumpers, etc The capacity of each lorry may be from 2½ cu. yds to 10 cu yds Assuming a speed of 20 miles per hour, length of haul 1 mile, the capacity of the lorry 2½ cu yds, the time of round trip 6 minutes travelling, 5 minutes filling and 5 minutes unloading, a total of 16 minutes, the output will be 75 cu yds. per 8 hour day With a hire charge for the vehicle of 50/- per day, the cost will be 8d per cu. yd. Any reduction on loading and unloading time will increase output and reduce cost.

The advantage of using lorries is that they can be taken onto any ground capable of supporting them; they can dump end or side, and assist in compacting the filling over which they travel Their disadvantages are inability to travel on soft or wet ground, and to break up large lumps of earth or chalk, to rut and disturb the formation, and to dump the spoil in heaps which require spreading afterwards, whereas the scraper dumps in thin layers. The bodies should be steel-

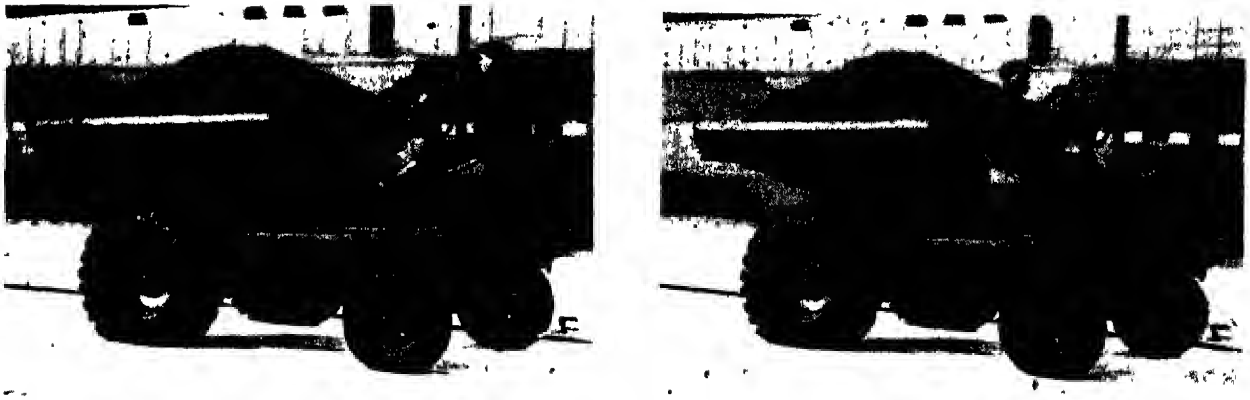


FIG. 1.—4½ CU. YD. SHUTTLE DUMPER SHOWING REVERSIBLE DRIVE

(Aveling-Barford Ltd

lined and capable of being tipped to a steep angle to clear themselves. The larger lorries of 10 yds capacity are fitted with eight to ten wheels to distribute the load, and have a greater range of speeds in the gear box.

DECAUVILLE TRACK

This is a light railway of about 2 ft. gauge consisting of flat-bottomed steel rails jointed with steel fish plates, and laid on steel sleepers. The wagons used thereon are usually of steel (½ yd. to 2 yds capacity), side-tipping. Tipping requires manual labour and spreading of the dumped material is required independently. The gradient should not exceed 1 in 20 owing to the danger of wagons skidding on the rails and to the power required to haul. The wagons may be drawn by horses, tractors, petrol, steam or Diesel locomotives which are usually from 20 to 40 h.p. Careful attention to packing, slewing, fitting crossovers, turntables, etc. is necessary. A 20 h.p. petrol locomotive will pull from 10 to 12 cu. yds. on a level track at a speed of about 8 m.p.h. Assuming a length of haul of 1 mile, a travelling time of 15 minutes, and adding 15 minutes for filling and 15 minutes for unloading, a round trip for 12 cu. yds. will occupy 45 minutes, giving an output of 130 cu. yds. per 8 hour day.

The yardage cost may be computed as follows.

Cost of hire of train, say £1 10 0 per day
Cost of hire of track, say £2 0 0 per day
Cost of maintaining track
and unloading wagons £2 0 0 per day

£5 10 0 per day for
130 cu. yds. = 10d. per cu. yd.

On the Farnham By-Pass a mechanical scraper dug, transported, dumped, levelled and compacted excavation for 10d. per cu. yd. To keep an excavator digging at an economical rate of say 80 cu. yds. per hour, when length of haul is 1 mile, at least five locomotives and fifty wagons would be required with sufficient track to avoid any standing time of locomotives. One advantage of this form of transport is that the rails can be carried across trenches, rivers and gaps as the rails assist as girders. Its limitations are the cost of labour required for maintenance and unloading, restricted gradients, possibility of derailment stoppages, time taken in slewing tracks and lengthening same, and the limited scope of tip.

DUMPERS

Dumpers of the Muir-Hill type can travel over softer ground than lorries owing to their larger tyres. The body capacity is 2 cu. yds. and the speed up to 12 m.p.h. Under normal conditions the output of a 2 yd. machine on a 250 yd. haul would be 25 cu. yds. per hour, allowing 3 minutes for loading and unloading, so that four dumpers should keep a 1 cu. yd. shovel working economically on a 250 yd. haul.

The cost of hire works out at about 15/- per hour or £6 per day; with an output of 25 cu. yds. per hour the cost would be 7d. per cu. yd. per 250 yd. haul.

As dumpers deposit the spoil in heaps, subsequent spreading is required, preferably by bulldozer. Although these machines assist the consolidation of the filling, they are liable to disturb the formation and create ruts, etc.

Fig. 1 shows a new type of Diesel shuttle dumper with reversible drive, thus increasing the rate of output by reducing the running time.

FIG 2 - 1 CU YD "440" EXCAVATOR AT WORK
(*Ransomes & Rapier Ltd*)

MECHANICAL EXCAVATORS

These essentially consist of a power-operated bucket fitted with cutting teeth, all movements being controlled by the driver through the medium of clutches, gearing, wire ropes, etc Power is provided either by steam, petrol, Diesel, or electric motor. Buckets vary in capacity from ⅜ cu yd to 30 cu yds, the usual sizes used for road work being ⅜ to ½ yd, ¾ to 1 yd. and 1½ to 2 yds. The machines, one of which is illustrated in Fig. 2, are usually mounted on caterpillar tracks and can be moved by their own motors, but are stationary while digging. The ½ yd. petrol type consumes about 2 gall. of petrol per hour and absorbs about 45 b h p. The steam-driven ¾ yd type consumes about 2 cwt. of coal and 100 gall of water per hour. Provided the machine is not kept waiting for transport the output of a 1 yd bucket should be 80 cu yds. per hour and of other sizes in proportion

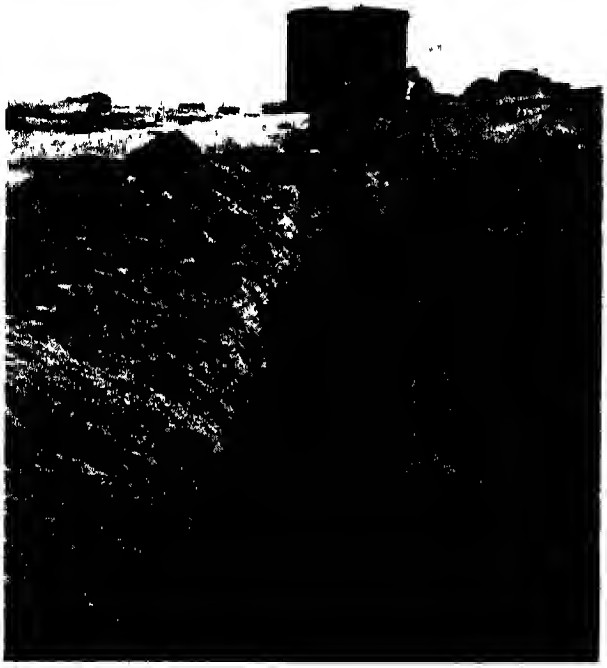


FIG. 3.—"SEVEN" EXCAVATOR, WITH BACK-ACTING TRENCHER ATTACHMENT, AT WORK
(*Thos Smith & Sons [Rodley], Ltd*)

Most machines are adaptable for easy change-over to work as (*a*) face, (*b*) back-acter, (*c*) grab or clam shell, (*d*) dragline, (*e*) skimmer and (*f*) crane.

The face type, most commonly used, will dig very heavy material, including rock if first loosened by explosives It is most economical when working against a face 8 to 10 feet high above the ground level

The *back-acter* (Fig 3) is a single bucket excavator digging below its own level, and will dig heavier material than a dragline; it is largely used for digging trenches up to 15 ft deep

The *grab*, illustrated in Fig 4, is used chiefly for digging below water level, rehandling loose material in stock piles, emptying wagons, and filling hoppers or vehicles

The *dragline* (see Fig. 5) digs below its own level for depths up to 20 ft If fitted with a long boom it has wide dumping and digging ranges It is useful for forming banks by digging from borrow pits

The *skimmer* is a single bucket excavator, the bucket sliding on a horizontal boom; it is used for shallow cuts and in cases where a clean level surface is required

For use as a *crane* the power of the motor is used for lifting or lowering material by fitting a swivelling hook to the end of the wire rope passing over the end of jib or boom

TRENCH EXCAVATORS

These machines are usually of the self-propelled multi-bucket type, the buckets being fitted with teeth to dig into the earth and mounted on an endless chain or revolving wheel The buckets discharge on to a conveyor belt which discharges the soil clear of the trench. (See Fig. 6.)

When using a stationary mechanical excavator loading into dumpers or lorries, the cutting should be excavated across the whole face. If the excavation is too deep for one cut, the work should be done in tiers so that lorries can gain access to the excavator. A sufficient number of lorries should be supplied to keep the excavator at work,

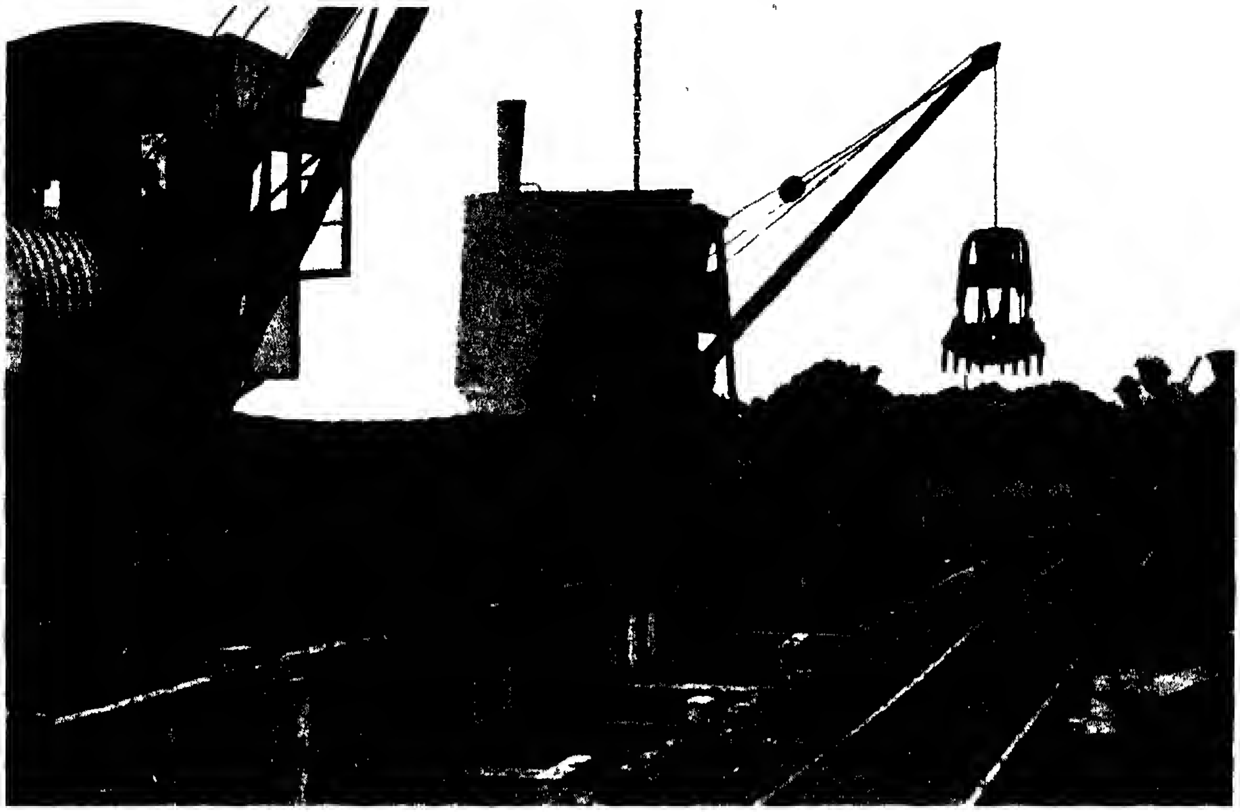


FIG 4—WHOLE TINE CLAY GRAB IN ACTION

(*Priestman Bros Ltd*)

one always ready to be filled The levels of cut should be frequently checked and the formation kept clear of standing water The excavator should have a weekly inspection to obviate mechanical breakdowns. Spare parts liable to be frequently required, i e. ropes and teeth, should always be held in stock at the depot

MOVABLE EXCAVATORS

These comprise graders, bulldozers, angledozers, rooters, rotary and box type scrapers, normally drawn by caterpillar tractors.

GRADERS

These may be towed or self-propelled The towed type consists of a steel blade supported on a framework mounted on four wheels with means of tilting, swivelling, raising and lowering the blade, which, set at an angle, pushes the earth forwards and sideways, thus forming windrows or filling channels, trenches, or broadening embankments

The self-propelled grader (Fig 7) is the same in principle but the vehicle is usually of a larger type and capacity, the wheels being fitted with pneumatic tyres. It is useful for spreading dumped soil

TABLE I

SIZES AND CAPACITIES OF EXCAVATORS

Bucket Size	*Weight (Tons)*	*When dumping*		*When cutting*	
		Max. Height (Feet)	*Radius (Feet)*	*Max. Radius (Feet)*	*Height at max. radius (Feet)*
$\frac{1}{2}$	7-8	11-12$\frac{1}{2}$	11-13	16-17	13-14
$\frac{3}{4}$	25-26	17-21	19-20	25-27	20-22
1	35-36	18-20	20-26	29-31	24-26

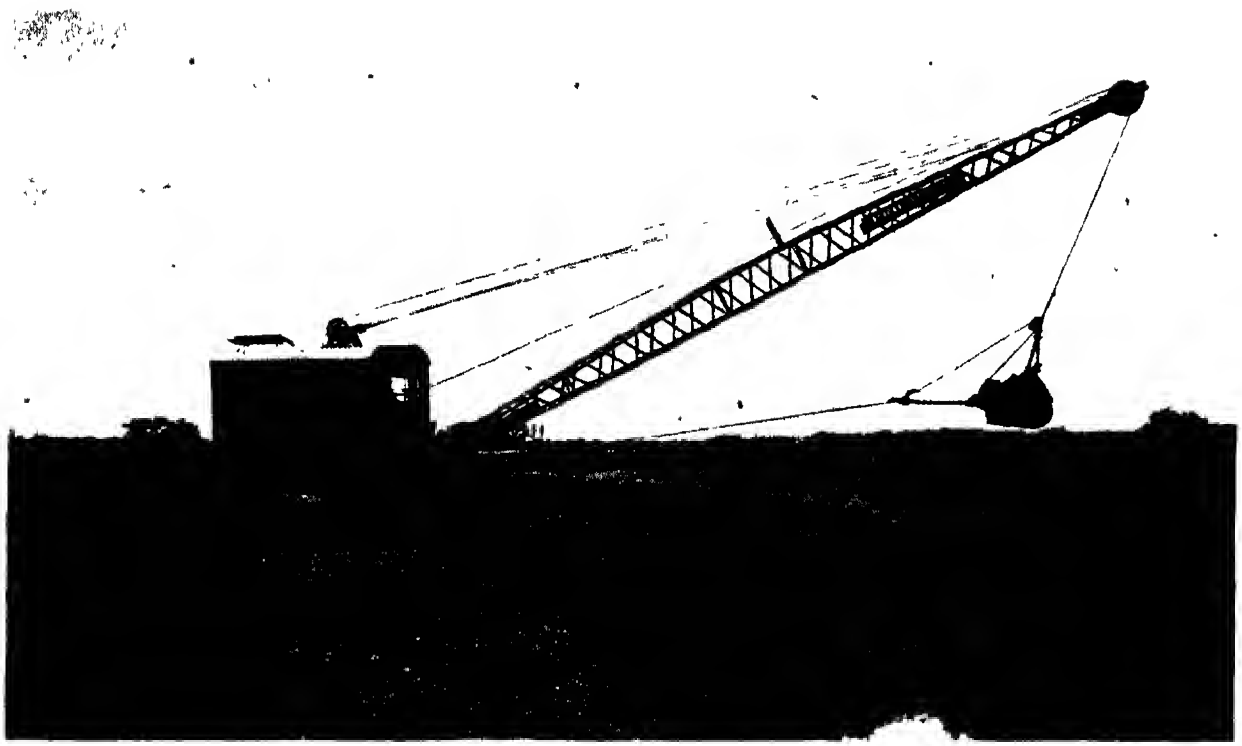


FIG. 5.—DRAGLINE EXCAVATOR

(Priestman Bros Ltd)

or loose macadam, trimming slopes and verges, all operations being under the control of the driver, whereas on the towed type an extra man is necessary to work the grader. When lorries or dumpers are used to carry excavation from stationary excavators and the formation becomes rutted and uneven by their passage, a blade grader should be run over the surface to relevel it, thus facilitating the lorries breaking track and producing more uniform compaction of the filling A bulldozer or angledozer will do the same but the cost of a small blade grader is much less than that of a bulldozer.

ELEVATING GRADER

This machine consists principally of a disc plough which turns a strip of earth onto a conveyor belt which may be 4 ft wide and 18–24 ft. long The belt, running at right angles to the travel of the plough, delivers the earth into lorries which must travel in the same direction and at the same speed as the grader. The ground must therefore be suitable and sufficient space must be available.

Under favourable conditions these machines can dig and load 400 cu. yds. per hour at no greater cost than a stationary excavator. They are usually towed by caterpillar tractors and require a driver in addition to the driver of the tractor This type of machine is only suitable for very large quantities of excavation and in circumstances where sufficient transport is available to remove the excavation, or where the excavation can be dumped in a windrow and left For hard chalk or other rock which the plough will not cut, it is of course unsuitable and in wet sticky clay trouble is caused by clay sticking to the belt, etc.

BULLDOZER

The principal feature of this machine, illustrated in Fig 8, is a steel cutting and pushing blade mounted on a steel frame and pivoted to the framework of a trackless tractor. The blade is at right angles to the line of travel The machine is used for pushing and levelling earth, ballast and rubble, for filling craters and trenches, levelling road formations, pushing down hedges, trees and obstructions, and clearing sites.

When dumpers or lorries tip loads of material into heaps the bulldozer is the most economical method of spreading and levelling the heaps, but the distance the material has to be moved should

not be excessive For distances greater than 200 ft. a scraper is to be preferred Skill and practice are essential in driving in order to obtain efficiency and economy. When using the machines the following points should be remembered. Push downhill whenever possible, avoid getting bogged and for levelling drop the blade and drive the tractor in reverse gear Adjust the height of blade above ground to that which enables the machine to move, so avoiding stalling the engine and skidding the tracks When pushing down trees, if the tree and roots are too large for the tractor to move, cut the roots of the tree, and push a ramp of earth by dozing about 3 ft up the trunk Lift the dozer blade to maximum height and operate the clutch so as to give a rocking motion to the tractor An alternative method is to use a power winch fitted to the rear of the tractor and pull the tree over by wire rope After the tree is down the dozer will clear it away and may assist in rolling it on to a timber wagon Bulldozers have many uses other than earth moving, e g erecting concrete mixers on staging, lifting heavy blocks, and pushing girders into the required position

Angledozer

The essential difference between this machine (shown in Fig 9) and the bulldozer is that the blade is set at 30° instead of square, the effect being that material is pushed sideways as well as forwards It is useful for forming embankments or working in narrow widths, clearing snow off roads, and forming windrows.

Rooter

This machine is a heavy scarifier, usually having three teeth mounted on a steel frame on wheels When using a scraper for earth moving and the ground is too hard for the cutting edge, a rooter is used to break up the ground before using the scraper It will break up hard clay, chalk and water-bound macadam The teeth are adjustable for height and depth

Wheeled Scraper

There are several types of this machine, one of which is illustrated in Fig 10, operated by a wire rope, the power being obtained from the caterpillar tractor, which tows the scraper and is fitted with a winch at the rear end

The relation between capacity and horse-power is as follows

Scraper Capacity in cu yds	*Tractor Horse-power required*
4	40
6	60
8	80
10	100

Machines of this type, with capacities up to 25 cu. yds are being used

A scraper is essentially a digging and transporting

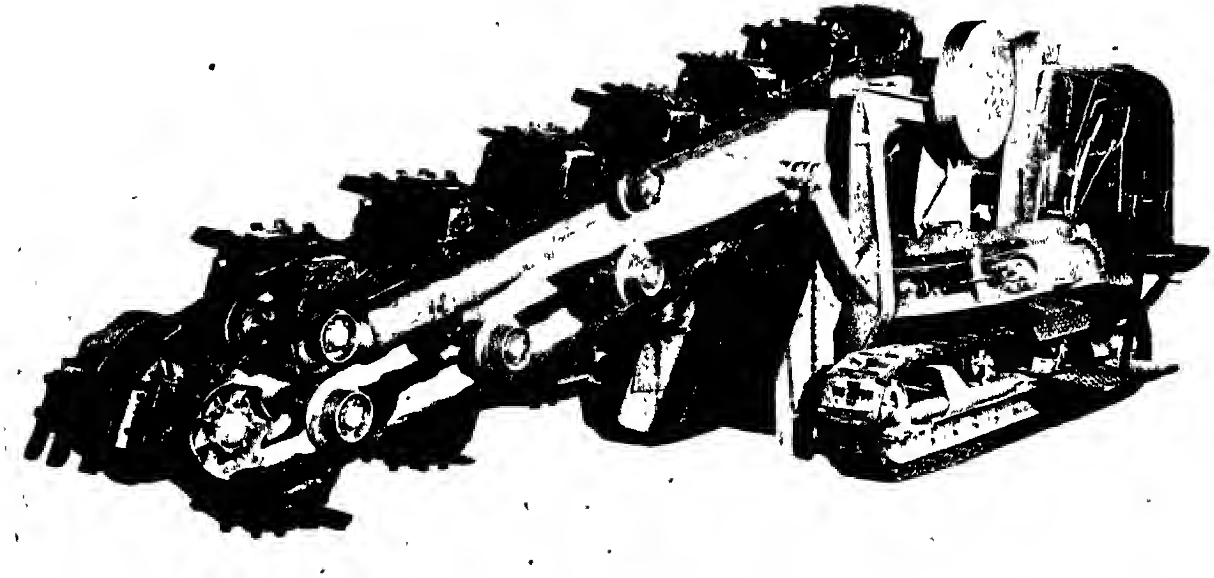


Fig. 6.—Buckeye "410" Trencher

(Buckeye Traction Ditcher Co)

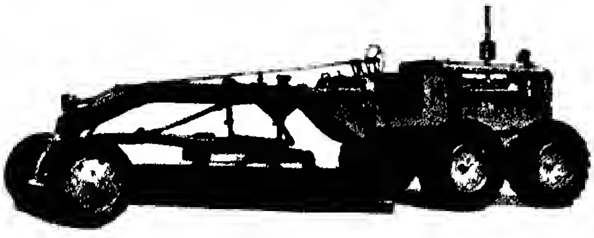


Fig. 7.—Caterpillar Diesel No. 12 Motor Grader
(*Jack Olding & Co., Ltd.*)

machine, and is economical for runs up to about 500 yds. The cutter of the scraper leaves a level surface. The passage of the tractor and scraper assists materially in the compaction of the deposited material which can be laid in thin uniform layers. The thickness of cut can be controlled by the height adjustment of the cutting blade. The output depends on the class of material being dug, the weather, the length of haul and the skill and experience of the driver, who is solely responsible for all operations both of tractor and scraper. On the Farnham By-pass the material dug was closely packed sand, easy to cut and discharge. Using an 8 yd. scraper towed by a D.7 tractor, cutting, filling, transporting and

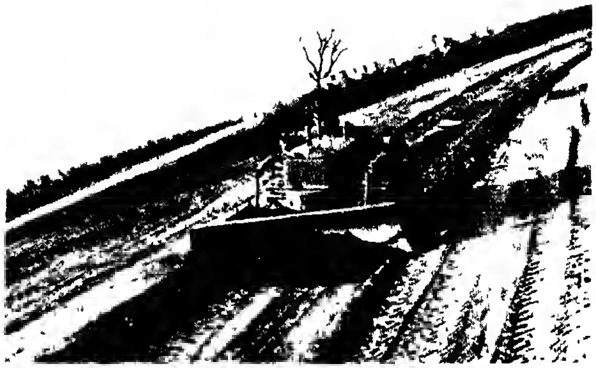


Fig. 9.—Angledozer fitted to TD-6 Trac-Tractor
(*Ruston-Bucyrus Ltd.*)

unloading occupied twelve minutes for each trip, the length of haul averaging 400 yards. The output was therefore 40 yds. per hour. In harder material the rate of cutting and filling is slowed, and the time of discharge may be increased if material sticks to the box. Points to remember in operation are: Always cut downhill whenever possible. See that the bucket is filled to capacity. Look out

Fig. 8.—Bulldozer fitted to TD-6 Trac-Tractor
(*Ruston-Bucyrus Ltd.*)

for pegs which must not be disturbed, and for solid obstructions which may damage the cutting blade. When digging a road cutting always start at the sides and work in to the centre, maintaining a cambered formation to assist drainage Relieve the strain on the wire ropes whenever possible, e.g. by lowering the bucket when standing idle. Inspect the cutting edge of the blade weekly and report wear. Do not use oil on the wire ropes, which work better not lubricated. When depositing material for embankments, tip at the outsides and work to the centre, maintaining a hollow surface which helps provided, as the capital cost and standing charges are heavy and a large degree of efficiency in output must be maintained to give economy.

A development of a track-type tractor is a high-powered tractor unit mounted on one axle with two wheels shod with pneumatic tyres. It works in a similar manner to a caterpillar track-type tractor but the speed has been increased to 14 or 15 m p h It is fitted with the same type of power winch as the track-type tractor and can operate a scraper up to 45 cu yds. capacity, or haul a loaded dump wagon of that capacity. Smaller models are available to haul 12–15 cu yds.

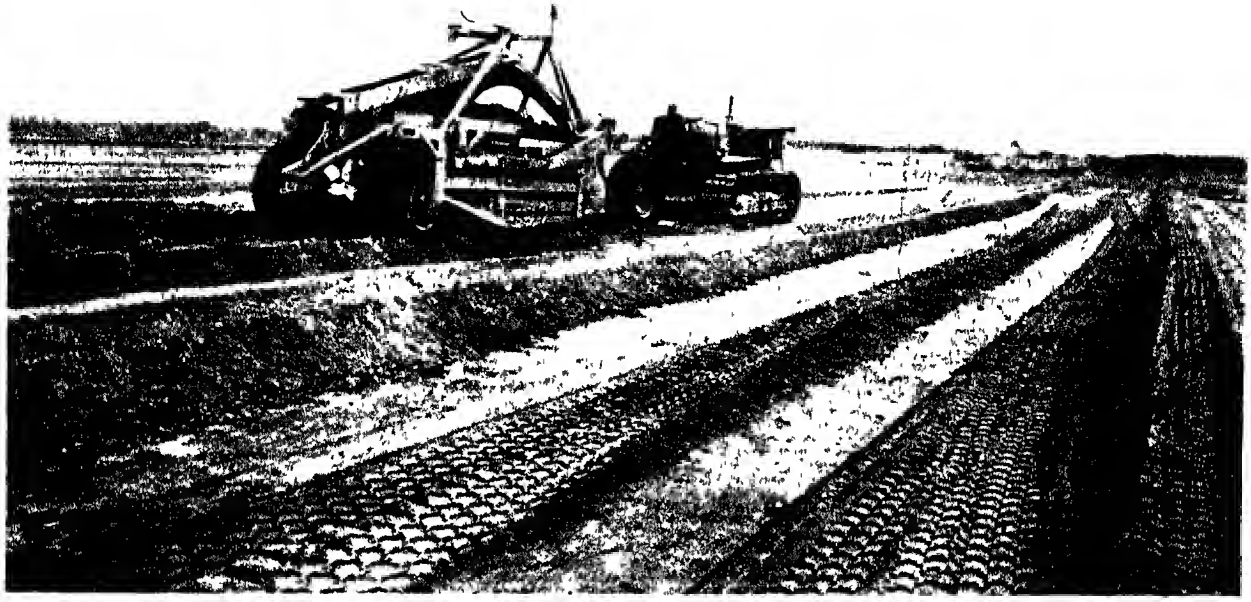


FIG 10 —D 8 "CATERPILLAR" TRACTOR WITH "LE TOURNEAU" MODEL LP

(*Jack Olding & Co , Ltd*)

to prevent the tractor sliding off the bank and assists in retaining moisture in the filling for the purpose of compaction If possible, break track on separate journeys to assist compaction Check tyre pressures. It is important that the pressure in all tyres should be equal to keep the scraper level and therefore cut level. It is not good to unload a full bucket when the scraper is stationary unless special precautions are taken to avoid undue strain on the wire ropes operating the tail-board. Drivers should be allowed adequate time for greasing and lubricating and running adjustments and a qualified fitter should examine the machine after about every 100 hours' use. Standing time should be minimized even if a second driver has to be

The scraper is mounted on two wheels at the rear, otherwise the method of operating the scraper is the same as with a caterpillar tractor. It is usual to have a caterpillar tractor pushing the scraper in addition to the machine towing it in order to augment the power and save time in filling the scraper which, when filled, is drawn by the latter to a distant point of discharge It can therefore be economically used for distances of haul where the tractor type would not be suitable, and is most economical on hauls of over 1,000 ft. As all wheels are fitted with rubber tyres, these machines can be used on existing highways in place of lorries and dumpers. The advantage over the tractor type is the greater speed of travel, with consequent increased output.

This machine can, of course, be used purely as a hauler towing previously-loaded wagons or other machines.

There are other types of wheeled scrapers, one being operated hydraulically, and another in which the load is tipped in bulk to the rear by turning the bucket over

Buckeyf Excavator

This machine consists of a wheel about 9 ft in diameter on which are mounted sets of cutting teeth and small buckets. The wheel is mounted on a frame which can be fixed to the side or rear of a road lorry The power for driving is obtained from the lorry back axle When working, the wheel is mounted at the side of the lorry and cuts into the soil to a width adjustable from 1 ft to 4 ft. and to a maximum depth of 12 in ; when using the road for travelling only, the wheels pivot back to the rear of the lorry. The buckets empty on to a conveyor which runs at right angles and can discharge into a lorry or on to the ground. A 3-ton lorry is required to supply power and take the excavated material The width of excavation is according to the width of bucket, which can be varied from 1 ft in 3-in stages Speed of travel can be varied from 5 to 16 m.p h

DUMP WAGONS

Wagons of the Muir-Hill type, comprising a petrol or Diesel engine mounted on three or four rubber-tyred wheels, and carrying a bucket in front which can be tipped to a steep angle to discharge, are available The buckets must be filled by excavators.

These machines can travel under worse conditions than road vehicles owing to their large diameter wheels and tyres A recent development in this type of machine is a six-wheeled vehicle with a body of large capacity, mounted on rubber tyres. The soil is discharged by opening the floor of the wagon which is in two halves and opens downwards on hinges. The floor is raised by a winch-operated cable. The machine is usually employed along with an elevating grader for filling the wagons or is filled by large capacity excavators.

MACHINERY FOR COMPACTION

After tipping soil on embankments or refilling trenches, it is essential that the filling should be compacted thoroughly to obviate settlement and damage to pavements. Various methods include (*a*) rolling loads; (*b*) percussion and (*c*) combination of both

Rolling loads include: three-wheel or two-drum rollers powered by steam, petrol or Diesel oil, wheeled scrapers, rollers built up of several rubber-tyred wheels, lorries and dumpers.

Types of percussion plant are trackless tractors, sheepsfoot rollers, dropping weights, vibrators

The manually-operated punner is useful in places where a larger machine could not operate and for very small work where it would not be economical to send a power machine, e g re-filling ground round a manhole, but for long drain trenches, the same size punner can be operated by compressed air or by a petrol engine with less human effort, greater speed and less cost.

ROLLING LOADS

Rollers

The use of the well-known three-wheel steam roller is almost out-of-date, except for finishing compaction already effected by tractors, sheepsfoot or by other means The disadvantage of this machine is that concentrated weight on smooth-tyred rear wheels sometimes fails to obtain a grip, and even when gripping, tends to push the filling forwards instead of downwards The tandem type has better distribution of weight but has also similar disadvantages, although it may be useful for finishing These considerations have led to the use of trackless vehicles for the first stages of compaction. The weight is spread over a greater area and is less per unit area, so that they are not so liable to get bogged.

The following comparison between two machines both of the 12-ton type, illustrates this point

12-ton Steam Roller (Weight on back axle, 8 tons; front axle 4 tons; driving wheels, 5 ft 3 in in diameter, 1 ft 6 in. wide, front roller, 3 ft 6 in in diameter, 4 ft wide).

Weight on Two Driving Wheels

$$= \frac{8 \text{ tons}}{2 \times 1 \text{ ft } 6 \text{in.}} = 2\tfrac{2}{3} \text{ tons per ft. lineal}$$

Assuming contact 6 in. wide on each wheel, this equals for the two wheels

$$\frac{8 \text{ tons}}{1\tfrac{1}{2} \text{ sq. ft.}} = 5 \text{ tons per sq. ft. approx.}$$

Weight on Front Roller (6 in. width of contact)

$$= \frac{4 \text{ tons}}{4 \text{ ft} \times 6 \text{ in.}} = 2 \text{ tons per sq. ft.}$$

12-ton Caterpillar Tractor (Tracks 6 ft. long by 18 in. wide).

Weight on both tracks

$$= \frac{12 \text{ tons}}{2 \times 6 \times 1\frac{1}{2}} = \frac{2}{3} \text{ tons per sq ft}$$

Tracks 20 in wide are available, still further reducing the pressure.

The output and maintenance cost of steam rollers will vary with age, weight and type of work undertaken, but an average comparison with petrol or Diesel rollers is as follows

STEAM ROLLER (12 ton)

Labour required	Two men (driver and mate)
Fuel .	Four cwts of coal per day
Water	300 galls per day
Cylinder oil	Two pts per day
Engine oil	Two pts per day
Grease	$\frac{1}{2}$ lb per day

Oil and grease for lubrication

Maintenance Requirements

Boiler tubes require cleaning daily After 100 hours' work, one full day required for cleaning boiler (washing out), packing glands and making adjustments

Output

Width covered	= 6 ft 6 in with the three wheels
Area rolled	= 200 to 400 sq yds per hour, depending on nature of soil

DIESEL ROLLER (12 ton)

Labour required	One man (driver)
Fuel	Four galls of oil per day.
Lubricating oil	$\frac{1}{2}$ gall per week

Small quantity of water for cylinder jackets

Output = from 300 to 600 sq yds per hour

The advantages of the Diesel type over steam are simplicity of operation, fewer working parts, economy in fuel both in quantity and in cost, no time is required for getting up steam and banking fire, the machine can be started up at a moment's notice, and there is a saving of fuel when standing by

Steam Rollers are available in working weights from 6 to 15 tons.

Petrol and Diesel Rollers from 2 to 16 tons

WHEELED SCRAPERS

Although not used solely for compaction, the passage of these machines over the earth they deposit does effect a large degree of compaction, provided the soil, its water content and the weather are suitable The towing tractors and the large tyres fitted to the wheels combined with the weight speed and number of passes, combine to increase output and efficiency. These machines may, under favourable conditions, fulfil the dual purpose of digging, hauling and compacting the filling

RUBBER-TYRED ROLLERS

These have been developed in America for use in compacting soils and consist essentially of four or more large diameter wheels shod with balloon tyres mounted on one or two axles and fitted with a platform so that the load may be varied One, two or three rollers may be towed by caterpillar tractor These machines, like wheeled scrapers, are not suitable for use on small areas

A similar machine has recently been developed in England, in which the rubber-tyred wheels wobble on their axles with the advantage that the tracks of the wheels are not straight and break the tracks of the other wheels This machine is illustrated in Fig 11.

Another development, illustrated in Fig 12, is a cylindrical metal roller, fitted with a petrol-driven engine which drives an eccentrically-loaded shaft at 2,500 r p m and causes the roller to vibrate while being propelled by hand The complete machine weighs $4\frac{1}{2}$ cwt, the roller being 1 ft 9 in diameter. Under test this machine has given good results on non-cohesive soils

LORRIES AND DUMPERS

The passage of these vehicles when used for hauling excavated materials over the filling assists in compaction, but the higher weight per unit area requires a harder formation to support them and their use cannot solely be relied on for proper compaction Drivers should always make a point of breaking their tracks and blade graders or bulldozers should be used to maintain as even a surface as possible during the passage of the vehicles so as to aim at uniformity in degree of compaction In the construction of the Mickleham by-pass, lorries of 6 yd capacity, mounted on three axles, were used for hauling excavation by mechanical excavators The rear axles were fitted with eight wheels driven through a gear box so that the lorry could traverse ground impossible to a four-wheeled axle These vehicles were, however, inadequate for compaction when the excavation consisted of large lumps of chalk, which required caterpillar tractors to break them down

PERCUSSION MACHINES

SHEEPSFOOT ROLLERS

These are of two types, the *clubfoot* and the *taperfoot*, illustrated in Fig. 13. This type of roller consists of a steel or cast-iron cylinder about 4 ft diameter and 4 ft long, with projections cast or welded on, projecting from 7 in to 9 in. from the roller The projections, called feet, are arranged in

FIG. 11 —RUBBER-TYRED ROLLER

(Fredk. A Pullen & Co)

rows, staggered so that four feet generally come into contact with the ground as the roller is towed by tractor The roller may be in sections, and each section may be filled with water to increase the load on the feet, which may vary from 50 lb /sq. in. to 500 or 600 lb /sq. in

A 4 ft wide roller empty might weigh two tons As the roller is towed, the feet come round and penetrate the soil perhaps to their full depth, but each successive passage is compressing the soil and the feet penetrate less until compaction is complete The surface is left rough and uneven and the use of blade graders or angledozers is desirable. An R D 7 tractor should easily tow two fully-loaded rollers Output under favourable conditions is 300–600 sq yds per hour. These machines are of very little use in wet clay, which is picked up and fills the spaces between the feet.

Dropping Weights

Various kinds of power are used to lift various weights. A 7 lb. punner manually operated would be useless on an embankment 30 ft high and 1 mile long—although very useful in small trenches of limited length Punners are operated by compressed air, petrol motor, or electric motor. A number of punners may be mounted on a chassis and lifted by a cam shaft driven by an internal combustion engine Metal weights may be lifted by a crane mounted on a tractor and dropped The Germans used (pre-war) weights up to 2 tons for compacting earthen embankments. They also used "Dingler" tamping machines fitted with 70 lb. punners lifted and dropped about seventy times per minute

Vibrators

There are various forms of vibrator, mainly used for compacting concrete. These will be dealt with more fully under the heading of "Vibrating and Finishing Machines", page 326. Briefly the machines or tools are virtually high-speed tampers

of relatively high frequency and low amplitude A compressed-air-driven road breaker or rockdrill may be used for compaction by fitting a punner in lieu of a drill. Enlarging on this system, a series of punners or a beam may be made to give a large number (up to 6,000) of blows per minute, the whole mounted on a chassis driven by an internal combustion engine If mounted on wheels, the machine is liable to become bogged; it is therefore preferable to mount it on a caterpillar

Vibrators are not always suitable for compaction of earth Tamping and punning may be quicker and more efficient on certain types of soil and under certain conditions For example, a vibrator would not be so effective on block chalk or clean gravel as a punner or tamper which would break up the lumps and reduce the voids

CONCRETE MACHINERY

There are various forms of concrete mixer, including the tilting drum, non-tilting drum, revolving drum fitted with blades, stationary drum fitted with moving blades, portable and non-portable mixers mounted on special lorries, mixers combined with batching plants, mixers mounted on chassis to run on rails, and mixers mounted on caterpillars

Drum-Type Mixers

Dealing with the well-known portable drum type, it is made in many sizes from $2\frac{1}{2}$ cu. ft to 112 cu ft batch capacity The British Standards Institution propose to limit the number of standard sizes to $3\frac{1}{2}$, 5 and 7 cu. ft tilting and 5, 7, 10, 14, 28, 56, 84 and 112 non-tilting type

Hitherto a mixer size has been designated by two figures, e g a 14/10 size has a capacity of 14 cu ft of unmixed and 10 cu ft of mixed concrete In future, only a single figure and letter will be used, e g a 7 T mixer will be a tilting drum mixer of 7 cu. ft. mixed batch capacity, whilst a 14 N.T. will be a non-tilting drum mixer of 14 cu. ft. mixed batch capacity.

The design of internal blades varies with different makers, as does the method of mounting and chassis details. Usually, a small water tank with syphon is supplied with the machine and is designed to feed automatically a specified quantity of water per batch by setting a valve Others are fitted with readable gauges to measure the water, but there is room for improvement in the means of adjustment to the fine limits necessary for good control of water/cement ratio.

Emptying the loading hopper into the drum and emptying the drum via the chute into barrows or

Fig 12 Cylindrical Metal Roller
(*Stothert & Pitt, Ltd*)

lorries can be difficult if the angle with the horizontal is too small Labour and time are wasted by hammering the loading hopper and raking concrete down the discharge chute. The time taken to mix a batch varies with the type of mixer and it has been proved that with some types, the strength of the concrete increases with the time of mixing Usually it is specified that the actual time of mixing shall be not less than one minute after all the materials have been loaded into the drum There is no object in reducing the time of mixing if the time of charging exceeds one minute. A cycle of operations for a 14 N T mixer would probably occupy five minutes, giving twelve batches or 6 cu yds per hour With a 56 N.T mixer, fed from hoppers by gravity through a batch weigher, an output of 40 cu yds. per hour can easily be obtained, giving an average of twenty batches per hour each taking three minutes per cycle.

Control of Mix

Generally, the larger capacity mixer gives a

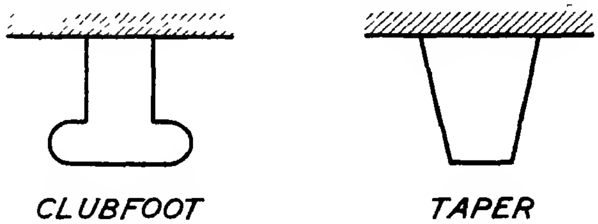


Fig 13 -Types of Sheepfoot Roller

more uniform mix because any errors in quantities of materials and water are less in proportion Normally, the portable type N.T. mixer has the loading hopper filled by hand from measuring boxes, but the volume method is being replaced by weight measurement. Most mixers are not fitted with apparatus for weighing but the large mixers used in Surrey are all fitted with weight batchers, and small separate weight batchers of 15 cu. ft. capacity have been introduced for use with 14 N.T. mixers All parts of the machine should be cleaned down at the end of the day's work to avoid cement setting and clogging the chutes, drum, etc It is a convenience if a batch can use one bag of cement to avoid measuring and splitting a bag. One bag of cement will be right for the following mixes and sizes of drums, i e a 1 :2 ·4 in a 7 N T. and a 1 :3 5 in a 10 N T Two bags of cement will be required for a 1 . 2½ · 5 mix in a 14 N.T This method is very limited, therefore an advantage accrues from the weight method in which all materials are weighed The measurement of cement in boxes by volume is not accurate, especially with small quantities

Mixers Mounted on Lorries

These machines are used in conjunction with fixed weigh-batching plants. The batch without water is loaded into the mixer at the fixed plant so that mixing can be effected at any part of the journey or on arrival at delivery point. There are two types in use, the non-tilting drum and the tilting drum The quantity of water used in the mix in both types is controlled by the driver who may have little interest in the control of the water/cement ratio and may use the same quantity of water for all mixes without regard for the moisture content of the aggregates.

This type of machine is useful where the central batching plant is properly controlled, but the discharge of the mixture leaves room for improvement. One advantage is that the mixing can be spread over a longer time but this advantage will disappear when mixers are designed to give a perfect mix in say 30 seconds Mixed concrete can easily be transported from a central fixed plant up to a radius of 15 miles in tipping steel-lined lorries, provided no time is wasted en route or at the point of discharge Dry mixes suffer less from segregation during transit than wet mixes. All concrete is difficult to discharge even from lorries and much time and labour is wasted in emptying. The Germans mounted their mixers directly over the formation. The mixers discharged direct into mechanical spreaders and the vibrating or tamping machine followed immediately behind to compact the concrete Two machines (*a*) the mixer and spreader combined and (*b*) the compactor easily lay and finish 1 mile of concrete 24 ft wide in one day. The mixer and spreader has to be supplied with batches of aggregate and cement which are made up at a central plant and transported in rail skip wagons which discharge each batch into the loading hopper of the machine The compactor may be of the "Dingler" type or the high frequency vibrating type. The control of the water/cement ratio is by the driver of the mixer but the man in control of the batches at the central batching plant determines the amount of water in the aggregates and specifies the amount of additional water required if any is to be added by the mixer driver Much lower water/cement ratios were used by the Germans than was our practice and consequently stronger and more uniform quality concrete was produced The Americans have developed large portable mixers of up to 4 cu yds. capacity mounted on caterpillar tracks and fitted with non-tilting vertical drums (two of 2 yds each). The advantage of the dual drum is that the first drum can be loaded while the second drum is mixing and the output of the dual drum type is greater than the same capacity single drum

With these machines the batching has to be carried out on a separate plant The discharge may be direct onto the formation or by means of a large bucket travelling on a steel boom on a swivel The machines require large quantities of water per daily output and special tank lorries are necessary to keep them supplied.

Another type of concrete mixer consists of a stationary drum mounted horizontally, with an open top, in which there is a vertical central shaft fitted with arms, to which are fixed moving blades, steel bars and rotating heavy wheels. The drum is loaded in the same way as an ordinary non-tilting vertical drum type, but the discharge is through the bottom of the drum. The great advantage of this type of mixer is that the loading hopper can be elevated to an almost vertical position, thus facilitating the discharge of the aggregates; the discharge of the mixed concrete is facilitated by the bottom discharge by gravity, assisted by the action of the moving blades. This type of mixer has been used for the special purpose of mixing soil and cement and has proved capable of giving an efficient mix in about thirty seconds with a 10 cu. ft batch.

The mixer is not fitted with any water control arrangement, nor with any weighing apparatus

for the aggregates and cement, and a separate weigh-batcher is therefore required. The weigh-batcher, if filled by manual labour, holds up the output of the mixer and gravity feed or mechanical loading is required to get the best output from the mixer, which is capable of producing about 20 cu. yds. per hour. The mixing drum is supported on steel stanchions 10 ft. high in order that a lorry may be filled from the discharge, and the power is supplied by an independent engine. The mixer, however, is not fitted with wheels, but is transported from place to place on a low-loading trailer.

In another type of mixer the drum is horizontally mounted with a vertical shaft at the centre, fitted with radial arms, moving blades and stars; the blades and stars revolve in one direction, and the drum itself revolves in the opposite direction. These mixers have been proved to be capable of giving an efficient mix in much less time than the vertical drum type and have the great advantage that they can be loaded from the top and discharged from the bottom more quickly than the vertical drum type with central loading and discharge.

Continuous Mixers

During the war, mixers designed to give a continuous output as against a batch output came into use where large daily outputs were required for speed of construction for runways. The principles involved are to feed the aggregates, cement and water separately through suitable feeders and gates for measuring the volumes. These machines produce a continuous mix and large output but accuracy of control is difficult to maintain, tending towards lack of uniformity and departure from specification.

Batching Plants

Batching plants are used principally for weighing out and combining the aggregates and cement and may be used in conjunction with or separately from the concrete mixers. A batching plant consists of at least two hoppers, one for coarse aggregate and one for fine aggregate. The aggregates in the hoppers discharge by gravity through a gate into a weighing pan which runs on rails and when the specified weight of aggregates has been obtained, the pan is emptied into the mixer; the cement is weighed separately and discharged into the pan with the aggregate. If the plant is a batching plant only the weighed batch is discharged into a skip or lorry and transported to the mixer, where the water is added.

The use of separate batching plants can only be justified where large quantities of concrete and large daily outputs are required, but they have the great advantage that the quality of the concrete can be strictly controlled by the weighing of the aggregates and cement under the supervision of one man at the plant, whose duty would be to ascertain the moisture content of the aggregates and decide on the amount of water to be added to comply with the specification.

Efficiency of Mix

Hitherto there has been no standard laid down as to what is meant by an efficient mix of concrete and it is astonishing that the efficiency of the mix varies with different makes and different types of mixer and with the period of time allowed for mixing. It is hoped that in the near future a standard of performance will be laid down by the British Standards Institution and that every mixer will be labelled to indicate:

1. The number of revolutions of the drum per minute.
2. The minimum number of revolutions required to give the standard of efficiency of the mix.

It is also to be hoped that in the near future the problems of clearing the loading hopper and the discharge chutes will be overcome and that the producers of the mixers will see that the necessary testing and weighing apparatus suitable for their particular machines is available. The testing apparatus should comprise a pycnometer or other instrument for ascertaining moisture content; an apparatus for testing the efficiency of the mix and apparatus for accurately controlling and varying the quantity of water per batch.

Concrete Spreaders

Mechanical spreading of concrete for large areas is advisable for the following reasons:

1. If concrete is to be compacted by machine, the rate of feed is much too heavy for manual labour.
2. The thickness of the concrete must be uniform and correct allowing for compaction.
3. The concrete must have uniform density before compaction otherwise the vibrating beam will ride on high spots, inadequately compact low spots and an uneven finish will result.
4. Treading on the concrete which produces uneven compaction and density is avoided.
5. It is less costly than using manual labour.

Spreading machines are of various types and may be combined with, or separate from, mixers and finishers. Separate machines which spread only may be of the box gravity type or fitted with some mechanical means for actually spreading the concrete.

Box-Type Spreaders

These consist of a steel frame mounted on flanged wheels to run on steel forms. On the frame a steel box about 12 ft. long, with a capacity of about 2½ cu. yds. mixed concrete, is mounted so as to be capable of movement across the width of the slab. Its movement is effected by a system of pulleys and wire ropes actuated by a clutch. The box is filled along the edge of the slab from side-tipping lorries, and when filled the driver lets in the clutch; a twin-cylinder engine provides the power to pull the full box across the slab (about 11 ft. wide). During its movement the box empties by discharging the concrete by gravity through the open bottom and the steel edge cuts off the spread concrete to the required thickness. The thickness of concrete is governed by the height of the bottom of the box above the sub-crust or formation, and the height can be varied by lifting or lowering the whole box by means of screw jacks at each end of the frame. The frame is mounted on two axles and four wheels and the power of the engine is utilized through clutches and chain drive to propel one of the axles to move the whole machine along the rails.

The spreading is effected transversely. One loading of 2½ cu. yds. will cover about 10 sq. yds. 9 in. thick in a few seconds so that the capacity to spread exceeds the output of a large mixer. As an example, assuming that the average time required to fill and empty the box is five minutes, most of which is taken in filling from the lorry, the output would be 30 cu. yds. per hour, equal to the output of a 2 cu. yd. mixer. This type of spreader is most economical when the transport of concrete from the mixer by lorry is arranged so that there are sufficient lorries to avoid waste of time in waiting for concrete.

American spreaders of the separate type require the concrete to be dumped on the formation, and the concrete is moved and spread either by the operation of Archimedean screws or by small angledozers. The output of these machines is so large that portable large capacity mixers are required to keep them working economically. The disadvantage of the screw type is that the aggregates quickly wear the screws, which are costly to renew, and the machine is inclined to stall when faced with large piles of unspread concrete.

Vibrating and Finishing Machines

Fig. 14 illustrates one of the latest British types for compacting sub-crusts of lean concrete or stabilized soil and surfacings of concrete. The machine is variable in width from 8–22 ft., by means of the tubular and telescopic cross members, the full range being covered in three stages, i.e. 8 ft. to 12 ft. 10 in., 12 ft. 10 in. to 17 ft. 8 in. and 17 ft. 8 in. to 22 ft. The power unit is a 7 h.p. Diesel engine for the first range and a 14 h.p. Diesel for the two longer ranges, the engines being interchangeable on the chassis. The weight of the first range machine is 5¾ tons, the second range 6¾ tons, and the third range 7½ tons.

In all ranges the machine is towable on the road for transport to and from site of works. This machine compacts concrete previously spread by the box spreaders. The screeding board in front is fitted for use when concrete is manually spread. With machine spreading it is not required or should not be required if the spreading level is correct. The speed of travel can be varied between 1 ft./min. to 8 ft./min. forward and a reverse speed of 60 ft./min. is provided. Flanged wheels can be quickly changed for flat wheels so that the machine may run on a form one side and concrete the other side. The speed of travel and amplitude of vibration of the beam can be adjusted to suit the workability and thickness of the concrete.

The lower the water/cement ratio generally the slower the speed, which enables more compaction to be applied. The vibrating and screeding beams can be lowered to 10 in. below the finished surface, enabling compaction to be applied to the formation, sub-crust or concrete in two layers. The speed of travel should be such that a densely-knit surface hard enough to walk on is produced in one pass of the machine. It is undesirable to stop the machine during operation as the stop tends to cause waviness in the surface due to the plasticity of the concrete and its hardening while the machine is standing. In order to keep the machine working continuously the concrete should be spread at the rate of not less than 40 cu. yds. per hour.

Expansion joints should be so designed that the machine passes over them without stopping, otherwise waviness or difference in level is produced. The truth of the finished surface depends largely on the truth to which the forms are laid. The forms should be firmly supported to stand the load and vibration of the machine. The cost of spreading and compacting concrete 8 in. thick with the

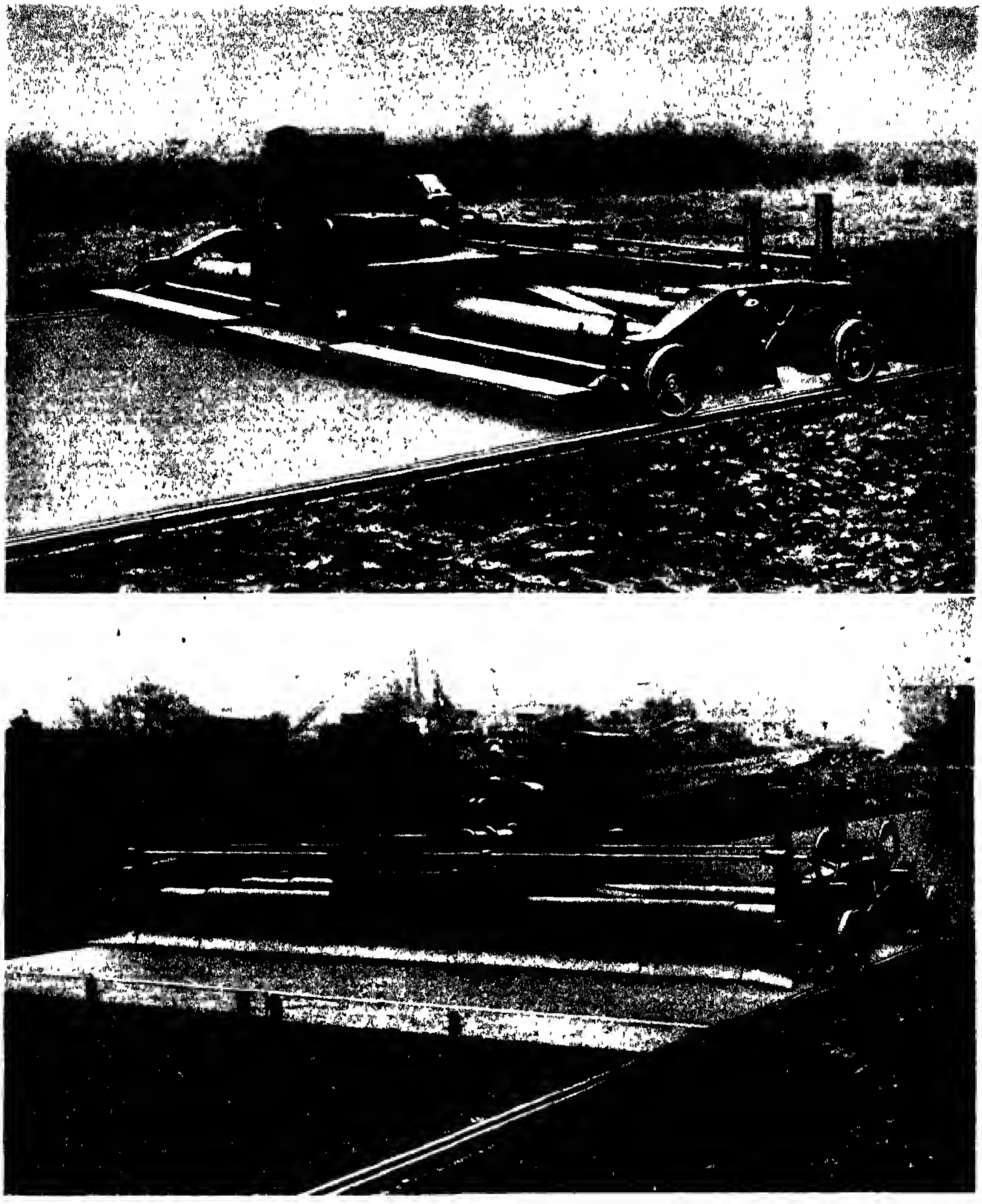


FIG. 14—VIBRATORY CONCRETE COMPACTING MACHINE
Top, rear view. *Bottom* front view (*Stothert & Pitt, Ltd*)

machine described is about one half the cost of manual spreading and compacting with manually-operated tampers, while the output is many times greater. There is no difficulty so far as the machines are concerned in laying 1,000 lineal ft, 11 ft. wide in one day, provided the work of mixing and transporting the concrete is organized to keep the machines at work. Wheels are fitted to the framework to facilitate turning the machine round The men driving machines of this type should have a knowledge of the quality of concrete used, the kind of finish required, the thickness and the permissible tolerance in levels, and should know how to use the machine to achieve the specified requirements of the engineer They should appreciate that the machine is not automatic Great skill is required of the driver to ensure that the machine is used to produce the desired result. It is quite easy to spoil good concrete by misuse of the machine, which will not achieve a good result out of bad concrete, nor will it correct errors in spreading the concrete The main object in using the machine is to compact concrete of lower water/cement ratio than is possible by hand and so to produce stronger concrete at less cost

Fig. 15 illustrates another type of vibratory concrete finisher, which is capable of compacting and finishing concrete roads from 8–15 ft in width It is powered by an 8 h.p Diesel engine The transmission of power is by friction-type variable speed unit to a secondary gearbox Working speed may be varied from 2–10 ft. per min. Travelling speed may be varied from 18–80 ft. per min The weight of the machine is 4 tons 7 cwt. for the 8–11 ft width, 4 tons 13 cwt for the 12–13 ft width and 4 tons 15 cwt. for the 14–15 ft. width This machine is an excellent compacting machine for use on concretes of low workability

Concrete Vibrators

The American and German machines follow the same principles of compacting by tamping, by vibrating beams or by a combination of both Some machines are little more than finishers, i.e. they are used for obtaining a smooth level surface on relatively wet concrete and would not compact concrete of low workability.

In addition to the heavy type of self-propelled machine, several types of mechanically-operated screed beams which are propelled or moved by two men, have been evolved in recent years. The simplest one consists of a timber iron-shod beam fitted with handles to which are attached two electric motors worked from a portable electric generator. These motors, about ⅓ h.p, have an eccentric weight (quite small) on the armature shaft, revolving about 3,500 r.p m and the eccentric weight causes the beam to vibrate. Alternatively, the motors may be replaced by pneumatic hammers driven by compressed air supplied by a portable air compressor The two hammers take about 30–35 cu. ft. of air per minute and quite a small compressor will provide this. Recently the timber beams have been replaced by steel beams about the same weight, the steel beams transmit the vibration better than timber, which tends to absorb some of it. These vibrating beams will compact relatively dry concrete, but the rate of compaction is necessarily slow compared with the more powerful self-propelled machine They are useful for small works and narrow strips of concrete such as haunching, and enable much leaner mixes of concrete to be used

As a guide to comparative costs of laying a machine-spread and vibrated concrete road 6 in thick (5 2½ 1 mix), the following is an indication of the expenditure.

	s	d	
Labour	2	0	per sq yd
Cement	2	5	,, ,,
Aggregates	3	0½	,, ,,
Plant		3¼	,, ,,
Haulage		6¼	,, ,,
Overheads	1	3	,, ,,
Total	9	6	per sq yd

It will be noted that the materials account for about 60 per cent of the cost

The labour charges include mixing, form laying, jointing, curing and everything necessary to complete the work Overheads include insurances, sick and holiday pay, supervision, depreciation of plant and H O charges.

The initial cost of a pneumatic or electric vibrating beam 11 ft. long is about £30. One beam will compact about 400 ft per day at most, if continuously operated and fed with concrete, but the lifting and operating is heavy work

Compaction of Concrete in Confined Spaces

For compacting concrete in structures, i.e. retaining walls, bridges, floors, arches, etc. there are two main types of vibrator, the external and internal, and varying methods of producing the vibration. In the external type the unit is held

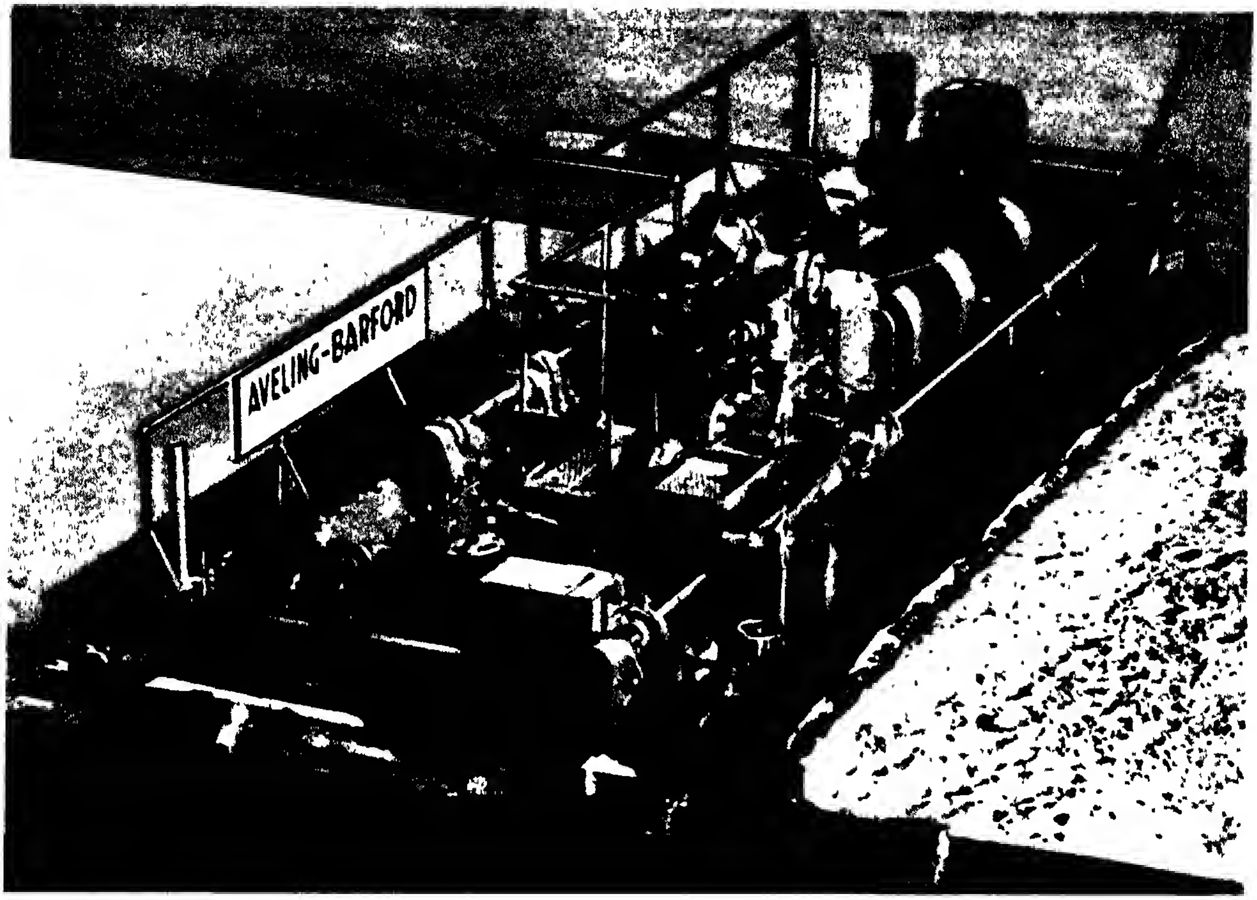


FIG. 15 VIBRATORY CONCRETE FINISHER

(Aveling-Barford, Ltd.)

against or clamped to the timber shuttering, the vibration transmitted through the shuttering to the concrete, the unit being driven either by electricity or compressed air. In the internal type a cylindrical tube of diameter varying from 1 to 4 in., is inserted in the concrete and the tube made to vibrate by a rotating shaft fitted with cams or eccentric weights driven either by electricity or by a petrol engine through a flexible shaft enclosed in flexible tubing. A small portable outfit suitable for small works has a 1 h.p. petrol engine fitted with handles for lifting, a length of flexible tubing and shafting about 20 ft. long and a steel vibrator say, 24 in. long by 2 in. diameter. The frequency can be as high as 3,500 per minute by introducing gearing between the engine and flexible shafting.

These units cost about £100 and have been used with excellent results on bridge work. Without them concrete has to be mixed with a much higher water content to ensure adequate packing round the steel reinforcement and much labour is expended in ramming the concrete. By use of these internal vibrators drier concrete can be satisfactorily compacted, thus saving cement and shortening the time during which the forms have to remain in position. The side forms of a beam can be removed within a few hours and used again, thus saving timber and reducing costs. The men operating these vibrators should be skilled in concrete technique as well as skilled mechanics. Any breakdown in the vibrator may have serious consequences if fresh concrete has been placed and not compacted when the breakdown occurs. In these cases, failing a stand-by vibrator, manual compaction would be resorted to and the day's work completed because the stoppage might occur at a place in the beam where the strength of the beam might be prejudiced.

The important points to observe in the use of these vibrators are:

1. Uniformity of concrete mix.

2. Correct workability of concrete to suit the vibrator being used
3. The time taken in vibrating should be just sufficient to ensure maximum density without causing segregation of the aggregates
4. The vibrator should be kept continuously on the move to avoid risk of leaving pockets when withdrawing the tube
5. The tube should be kept as low down in the fresh concrete as practicable

With regard to point 5, if a cu ft box is filled with dry concrete and the vibrating tube slowly

Fig. 16 S 6 Breaker in Action
(*Warsop Petrol Drill & Tools, Ltd*)

inserted to the bottom and withdrawn slowly, taking about 20–30 seconds, it will be observed that the 12 in depth of concrete will fall to 8 in or 9 in. due to compaction The resulting cube should be self-supporting on removal of the timber box if workability and time of vibration are correctly adjusted.

The use of concrete vibrating machines and mechanical spreaders requires the use of rails or forms stout enough to carry the weight and firmly fixed to obviate movement and vibration.

PLANT FOR SURFACE DRESSING

Mechanical distribution of tar, bitumen and emulsions is preferable to handwork, gives greater uniformity, control and speed. If a 250-gallon tar boiler equipped with pressure pump and jet spray is used, better control than by hand brushing may be obtained but the control is in the hands of the man holding the jet. If he holds the jet at varying heights uniformity of spread will be deficient. Spreading chippings by shovel also makes it almost impossible to obtain uniform rate of spread If tank pressure distribution is employed, it is so rapid that mechanical spread of grit must also be employed The normal method now is for the tar distiller to send the hot tar in 1,000- or 2,000-gallon tanks on road lorries fitted with steam coils to control temperature and to spray the tar direct from tank to road through a series of jets which can be controlled as to rate of spread

Machines of varying design are available for spreading the chippings * One type has a steel box, 6 or 7 ft long, mounted on a two-wheeled axle and drawn by a lorry The road wheels operate a screw propeller running along the bottom of the box and the turning of the propeller distributes the grit to the width of the box A weakness is that distribution depends largely on the manner in which the box is filled with chips from the lorry Wear on the propeller is heavy Another type has a steel funnel into which the chips are thrown from the towing lorry and at the base of the funnel is a revolving disc fitted with blades, the disc being geared to the road wheels The grit falling onto the revolving disc is flung by centrifugal force to a width adjustable up to 30 ft The rate of spread is governed by an adjustable gate in the funnel and by the speed of the lorry

In practice the machines are liable to damage by inserting stone of too large size which jams in the gate or damages the blades. Sometimes the grit tends to clog in the funnel and has to be assisted manually through the gate There is urgent need of a grit spreader which is so designed that the grit can be spread in front of the lorry to avoid the wheels passing over the tar

CRUSHING AND SCREENING PLANT

Stone crushers essentially consist of two steel jaws, one fixed and one knapping, and have the same effect as breaking the stone by hammer. The moving jaw is linked to an eccentric which

* See also article on Maintenance of Highways, page 405.

gives it the knapping motion. Crushers are driven by steam or petrol engines and vary in size and capacity A crusher 12 in × 9 in at mouth will break 5–6 tons per hour and require 10 h p A crusher 30 in × 18 in. will break 25 tons per hour and require 60 h p. For breaking down small stone say 2 in. to chippings a granulator is used The stone is crushed between a fixed steel inverted cone and a moving cone which has a gyratory motion imparted through bevel gearing The size of chips is regulated by raising or lowering the fixed cone which alters the width of space between the two cones A 20 in granulator requires about 25 h p and running at 650 revs per minute will give an output of 10–30 tons per hour depending on the size and hardness of the stone All jaws and cones should be of manganese steel and capable of being replaced when worn Crushers should be mounted firmly and level and if running parts are properly adjusted and lubricated, should run silently when not breaking stone Owing to the dust created, all bearings should be dustproof and kept properly lubricated and adjusted

Screens are used for sorting out broken stone into various sizes Rotary screens are cylinders of steel drilled with holes of various sizes Vibratory screens are flat or inclined metal meshed grids, the wires being spaced to give any required size The following standard sizes of square holes in screens have been adopted, viz $2\frac{1}{2}$, 2, $1\frac{1}{2}$ 1, $\frac{3}{4}$, and $\frac{1}{2}$in For $\frac{3}{8}$, $\frac{1}{4}$ and $\frac{1}{8}$ in and sizes below $\frac{1}{8}$ in, wire mesh screens are standard The vibratory screen is thought to be more efficient than the rotary because the stone remains longer on the screen, which gives a better chance of its passing through the mesh than being carried along by the rotary screen on to the next size Screens have a rated output depending on their length and diameter and inclination and should never be fed at a greater rate. A trouble with fine mesh screens or small diameter holes is clogging by damp stone Here the vibratory screen has an advantage

ROAD BREAKERS

The use of pneumatic tools has considerably accelerated road repair work, and developments in this field of equipment are continually taking place

The most common tool is, of course, the concrete breaker, which is usually of heavy weight and robust construction in order to stand up to the arduous conditions encountered in roadwork Breakers vary in weight from about 60 to 80 lb and are powered by a mobile air-compressor

Various attachments are now available as alternatives to the normal drill steel, such as picks, spades, trench rammers, clay diggers, etc, all designed for their particular purpose

A development in road breakers is a self-contained machine, illustrated in Fig. 16, which is powered by a petrol engine mounted at its head No auxiliary power is required, and this gives an advantage in portability and ease of working

TARMACADAM AND ASPHALT PLANT

There has been considerable development in this type of plant Manufacturers are continually aiming towards machines giving better output, whilst ensuring greater control of mix so as to work closely to specification Particulars of various machines, both of the stationary and mobile types, will be found on pages 335, 337, 340, 341, 345, 346 and 347

LUBRICATION OF MECHANICAL PLANT

The successful operation of any mechanical plant depends, almost entirely, upon the attention which is given to periodic maintenance Especially does this apply to the question of lubrication, particularly where moving parts are concerned

It is obvious then, that some definite schedule of routine application should be established, thoroughly understood and maintained Depending upon circumstances it may be possible, especially in cases where mobile oiling and greasing equipment is installed, to arrange that the lubrication of all machinery is carried out at regular intervals by a competent maintenance crew. Alternatively, the responsibility for this work can be left to the individual operator.

Whichever system is adopted, it is important that those concerned are fully conversant with the requirements of each machine, and this will entail careful study of the manufacturer's instructions which, when available, should be closely followed Once the correct routine has been established, and the proper lubricants selected, attention can be given to some of the problems entailed in their application

Cleanliness

The best lubricants in the world are easily rendered useless by the presence of dirt and grit which, if allowed to penetrate to working parts, soon results in excessive and expensive wear and tear of the parts concerned. All containers

and equipment, therefore should be kept scrupulously clean. Similarly, grease nipples, oil hole covers, etc., should be carefully cleaned before applying any lubricant.

The grease gun or oil-can should always be used sparingly; it is better to apply them sparingly but often, than to apply large amounts of lubricant at infrequent intervals. Oil wells, oil cups, and drip-feed oilers should be kept well filled, otherwise their rate of feed will slacken off.

Table A

LUBRICATION GUIDE

	Check up or Application	*Oil Change*
Plain Bearings		
Oil Hole	2 hours	—
Oil Reservoir	60 hours	600 hours
Grease Cup or Gun	4 hours	—
Ball and Roller Bearings		
Grease Gun	20 hours	—
Grease Packed	- -	600 hours
Gears		
Open	2 hours	—
Enclosed	60 hours	1,000 hours
Engine		
Crankcase Oil	8 hours	100 hours
Hydraulic System		
Hydraulic Fluid	8 hours	1 000 hours

Ball and Roller Bearings

These should never be more than three-quarters full, if overheating is to be avoided. Drain plugs (if fitted) should be removed before filling, and left open for a few minutes after greasing, while the bearing is running. Excess grease will then be expelled. In the case of high-speed packed bearings, these should first be cleaned out and then re-packed with fresh grease every three months or as recommended by the manufacturers. They should never be packed more than three-quarters full.

Engine and Compressor Crankcases

These should be topped up at regular intervals, dependent upon their condition, but in any case once every eight hours. The dipstick level should be checked every four hours.

Engine oils should be changed every hundred hours, compressors every two hundred hours, unless instructions say otherwise, and it is advisable to drain out the old oil when it is hot, such as immediately after a run. In this way the maximum amount of solid matter will be removed. Crankcases should never be flushed out with paraffin or diesel fuel; Flushing oil should always be used, but it should be ensured that no large quantities remain in the system afterwards. Engines using heavy duty detergent type oils seldom require flushing, but should this become necessary, a light detergent oil instead of Flushing Oil should be used. Careful attention should also be given to makers' instructions regarding the cleaning and changing of oil filters and oil filler packs.

Gearboxes

These should be drained and flushed out in the same manner as crankcases, before refilling with fresh oil. Unless otherwise advised by the makers, this operation should be carried out every six months.

Oil levels should be checked regularly, at least once a week, and topped up as required, but only to the indicated full-level on the dipstick. Should a leakage be suspected, a daily inspection should be made, until the cause is discovered and remedied.

Open Gears

These require regular inspection, and can with advantage be examined every two hours, when those tooth surfaces requiring more gear dressing can be given a fresh application. It is impossible to lay down any specific time for this operation, as it is entirely governed by the type of plant installed, but gears can be, and should be, kept under constant observation when running.

Oil or soft greases should never be allowed to get on open gear teeth, as this will ruin the adhesion properties of the dressing. Applications of dressing on top of oily or greasy teeth, for instance, will only result in rapid loss of dressing.

Roller Chains and Wire Ropes

Roller chains can best be lubricated by being removed from the drive and soaked overnight in a bath of lubricant. Oil rather than grease should be used for this operation.

Wire ropes should be brushed clean, and then painted or swabbed with lubricant as, like roller chains, they benefit by being steeped in a bath of lubricant.

It is only by soaking them in a bath of lubricant that vulnerable parts, such as the chain roller pins and innermost strands of wire, are adequately lubricated. It is not enough to cover them on the outside with oil or grease. Spare chains and ropes should also be stored in such a bath.

The Table A will serve as a guide for the maintenance of all plant, where no precise instructions are given by the manufacturers.

MANUFACTURERS' DATA ON ROAD-MAKING EQUIPMENT

ALLAM ROAD PLANT, LTD, LONDON, W C

THE ALLAM VIBRATING TAMPER is suitable for the consolidation of all types of concrete roads, especially secondary roads, and also for concrete areas The tampers are fitted according to their length with one, two or three Trillor Electric Vibrators, type V 350 and are supplied in any length up to 22 ft 6 in The Vibrators are wound for 220 240 volts single phase, 50 cycles or 110 volts, three phase, 50 cycles supply If there is no electric supply available close to the site small portable generating sets are provided to power the three-phase vibrators These generating sets are fitted with 3 h p petrol engines and supply up to six Trillor Electric Vibrators, type V 350 The power consumption of the vibrators is only 250 watts and a switch to control the vibrators is fitted directly to the tamper in easy reach of the operator The frequency of the vibration is approximately 3,000 r p m and the amplitude produced can easily deal with harsh and dry mixes The way in which the vibrators are mounted on the tamper tends to give the tamper an automatic forward movement Thus only two men are needed to guide the tamper along the forms The tamper is steel shod and fitted with anti-vibration handles (Plate I, No 1)

ALFRED ALLEN & SON, LTD, DUDLEY

"SWING" all purpose water cart, with welded tubular frame and heavily galvanized container, 15-30 gallon capacities Riveted steel crane skips, ½ 1½ cu yd capacities, made in both tipping and drop bottom types Tipping wagons with all welded bodies, ½ 2 cu yd capacities, bodies nest for economical transport Portable railway tracks, turn-tables, points and crossings 18-36 in gauges

EDGAR ALLEN & CO, LTD, SHEFFIELD

STAG JAW CRUSHERS of the Blake type can be obtained with either cast steel or cast iron bodies (Plate I, No 2)

In the cast steel type the body is made in one piece, or where transport difficulties may be encountered, it comprises four sections bolted together Breakers 42 30 in and larger are made with the body in sections Crushers of this type range from 12 6 in, with an approximate output, when crushing limestone to 2½ in and under of 4 to 5 tons per hour, to the 55×32 in machine, approximate output for which will be given on application

The cast iron body sizes range from 9 5 in, with an approximate production of 2 to 3 tons per hour, to the 30 × 18 in with an approximate production of 18 to 27 tons per hour A steel plate frame crusher is also made, the frame being built up in sections, and is designed for ease of transportation where the weight of maximum lift has to be considered

THE STAG GRANULATOR has been designed to produce a size of material 1 to ⅛ in, which is largely used for the surface dressing of roads, and for tar macadam Machines can be of either fixed or portable type, with or without screens

STAG CRUSHING ROLLS (Plate I, No 4), are essentially secondary crushers taking feed from jaw or gyratory crushers The usual reduction ratio is four to one Their advantage is minimum production of fines depending on the kind of material crushed, and the natural grain size into which it will break down The rolls are of two types, high speed and medium speed. Both devices can be fitted with shells having smooth, corrugated, or serrated faces, and can be used for either wet or dry grinding High speed rolls are made in sizes from 18 up to 42 in. roll diameter, with capacities ranging from 5 to 14 tons per hour when the rolls are set ¼ in. apart Medium speed crushing rolls are made in sizes from 18 to 36 in roll diameter, with capacities ranging from 8 to 20 tons per hour, with the rolls set ½ in apart

THE K B ROTARY GRANULATOR, a hammer mill, is an all steel machine, which will take a larger piece and crush it to an exceedingly fine product, it is designed to produce cubical chippings without flaky pieces, from stone, gravel etc for road making and concrete aggregates In some instances, it does away with the preliminary crusher, and can often handle wet or damp materials, thus eliminating the cost of drying before crushing

The hammers are of swing type, and made of Imperial manganese steel, being suspended from discs mounted on the shafts As the material is fed into the hopper, the hammers whirling around hurl it with tremendous force against the breaking blocks The rebounding fragments are caught by each succeeding hammer, and again shattered against the blocks Machines are made in four sizes, with maximum lift ranging from 3 to 60 cwt, and with an output on gravel, shingle, etc, from 4 to 40 tons per hour

THE STAG K B ROTARY PULVERIZER, swing hammer type, is an adaptation of the same machine, provided with screens

STAG BALL MILLS (Plate I, No 3), are specially suitable for the reduction of cement clinker, quartz, etc, and for preparing agricultural lime The mill is used for dry grinding on the screens Six standard sizes are made, and material up to 4 cu in can be fed to the largest mill The usual size of feed is about 2 cu in

ROTARY SCREENS —A typical example of this type of machine is the portable combined breaker and screen shown in Plate I, No 5 Other machines of any size up to 8-ft diameter for handling the hardest or most abrasive material are also available All machines incorporate interchangeable screen plates, while bearings and driving gear are so arranged that they are not exposed to falling materials The lubrication system also excludes grit and dust

The "IMPERIAL" SCRUBBER AND WASHER, illustrated in Plate I, No 8 works on the vibrating system, is operated by means of an eccentric drive, and is fitted with roller bearings The vibrating motion is positive and causes the material to be agitated in such a way that segregation is set up between the particles This, with the assistance of the washing water, causes a complete separation of sand, dirt etc, resulting in a clean product being obtained with marked efficiency

The whole machine is supported by means of strong springs at the four corners, on a frame which carries the main bearings, and in such a manner that the bearings are relieved of the bulk of the machine's weight The frame can be slung by means of cables and springs if desired, or can be bolted down to rigid foundations

ARMSTRONG-WHITWORTH & CO (PNEUMATIC TOOLS), LTD, GATESHEAD-ON-TYNE

Pneumatic picks and concrete breakers for general demolition, heavy duty and ripping work Pneumatic spade for clay digging and tunnelling Trench rammer for trench and road tamping Sump pumps for draining, excavations and sumps

ASSOCIATED EQUIPMENT CO, LTD, SOUTHALL, MIDDLESEX

A E C "MONARCH" freight carrier, powered by the A E C "7 7 litre" direct-injection 6-cylinder oil engine, has a body space of 20 ft and can carry a pay load of over 7 tons The chassis can be supplied with a 12 ft 1 in, 14 ft 7 in, or 16 ft. 7 in wheel-base to suit various requirements Used by many contractors for tar spraying work (See also "Manufacturers' Data on Maintenance Equipment and Materials", page 428)

ATKINSON LORRIES (1933), LTD., PRESTON

For general haulage of merchandise and road materials and for tar spraying the ATKINSON DIESEL ENGINE COMMERCIAL VEHICLES are well known They can be supplied with platform or tipping bodies, and long or short wheel-bases There are three types—7½ ton 4-wheeler, 12-ton, 6-wheeler and 15-ton, 8-wheeler

ATLAS DIESEL CO., LTD., WEMBLEY, MIDDLESEX

Pneumatic machinery and tools for Civil Engineering work of all descriptions Mainly interesting to highway engineers are concrete breakers, clay spades, demolition picks, backfill rammers and portable and stationary air compressors of all types and sizes ATLAS air compressors are diesel driven, and are standardized in every detail to ensure strict interchangeability of spare parts, which are always available from stock They can be fitted with solid rubber or pneumatic tyres, with brakes and high-speed towing gear if required Plate III, No 1 shows diesel driven compressor type MK 35D

AVELING-BARFORD, LTD, GRANTHAM

"G" SERIES, VARIABLE PRESSURE DIESEL ROLLERS, made in weights from 2½ to 13 tons in three chassis sizes, these rollers are equipped with movable weight device (patent) within the main chassis members The weight can be slid to forward or rearward positions In the front position, the roller weight is equally distributed over the front and rear rolls, and in the rear position, maximum consolidation on the rear rolls is obtained Water ballast type rolls are fitted Plate I, No 7 illustrates the G D Diesel Roller, and No 6 the G B Roller

4½ CUBIC YARD DIESEL SHUTTLE DUMPER An outstanding feature of this dumper is the patent reversible driving position which enables the driver to have the load either in front or at the back of him This feature enables the machine to be used in the public highway It has four speeds in either direction with a top speed of 16½ m p h (Illus Fig 1, p 313)

ONE CUBIC YARD DUMPER Manœuvrable and mobile on rough ground, the one-yard dumper plays a very important part in the transport of material on restricted sites where other four-wheeled vehicles cannot operate Tipping the load and resetting the body is controlled from the driving seat It is powered by a 16-b h p 4-cylinder petrol engine and fitted with a 3-speed gear box Maximum speed is 10 4 m p.h

THE CALFDOZER is a miniature bulldozer with a remarkable performance and has many uses, particularly on building sites It can be successfully employed for site levelling and clearing, back filling trenches and excavations, trimming stock piles and, with a special attachment, for turf stripping The blade, 4 ft 6 in wide, can be swung left or right for angle-dozing and power is supplied by an 8 h p industrial type petrol engine (Plate I, No 9)

TRENCH CUTTING MACHINE Designed to cut trenches 11 or 18 in wide to a depth of 3 ft 6 in for laying underground services, this machine will cut up to 175 ft of trench per hour according to conditions and size of trench It is self-hauled by a wire cable and the cutting speed is controlled. An 8-h p industrial type petrol engine supplies the power (Plate I, No 12)

DUMP TRUCK, consisting of a parent vehicle and loose hopper which can be picked up and set down at any point, this machine overcomes terminal delays in the transport of material on building sites and waiting at loading and discharge points is avoided Capacity of the hopper is ⅘ cu yd. The vehicle is powered by a 16-b h p 4-cylinder engine

W. & T. AVERY, LIMITED, BIRMINGHAM, 40

Self-contained weighbridges for installation in brick or concrete foundations, in a range of sizes to suit all traffic Batching scales with hoppers, and varied capacities for weighing aggregate, etc, for concrete and tarmac.

BARBER-GREENE

See JACK OLDING & CO LTD, page 346

BARRETT, TAGANT & GOTTS, LTD., LONDON, S.W.6.

"MAXIMA" high-grade lubricants for every purpose. Rust preventives with lanoline or petroleum jelly base, for the prevention of corrosion and rust on all types of road plant

BENFORD, LTD, WARWICK

THE B R 25 is a continuous type mixer, designed to produce 25 cu yds of mixed concrete per hour continuous working There is an additional reserve capacity of 10 per cent, but all users are advised to organize their jobs within the nominal output capacity At this rated output, all working parts of the machine are running within easy limits, and consequently the wear and tear on the plant is reduced to a reasonable minimum

Because the process is continuous there is never more than a comparatively few pounds of material being mixed at any given moment, thus ensuring the quality and consistency of the concrete

New Benford mixers are fitted with the "*Reguflo*" water control system which combines accuracy of measurement with simplicity in design and reliability in construction Another feature on all new mixers is the "*Spot On*" Sand Predictor, which is used for adding any pre-determined quantity of sand to the mixer, without stopping production (Plate I, No 10)

THE BENFORD REGULUS TYPE E CONCRETE MIXER has all the recognized advantages of a costly central mixing station or batching plant, and produces concrete up to 10 cu yds per hour when used continuously, the machine weighs only 25 cwt, and requires only 3½ h p driving power

The Regulus requires a very small space to work in, and is readily portable Once set, it automatically measures the required proportions of stone, sand and cement for mixes of any rate and does away entirely with pre-gauging With a discharge height of 27 in, it is suitable for discharge into single or double wheel barrows, while when adapted for use as a central mix-plant, it can generally be set up to discharge at a height to suit most types of concrete carts and trucks (Plate I, No 11

BLAW-KNOX, LTD, LONDON, N.W 1

DEWATERING EQUIPMENT usually comprises a diesel-driven 6-in suction centrifugal pump and has a vacuum pump incorporated in the plant for producing the high degree of vacuum necessary to ensure efficient operation A dewatering outfit of this type is capable of handling 60 wellpoints coupled to a header pipe 200 ft long and of dealing with a maximum of 60,000 gallons of water per hour under average conditions

EXCAVATING EQUIPMENT.—Whilst the mechanical excavator still has its uses, it is definitely limited when dealing with the construction of modern highways The tractor-hauled and self-propelled scraper is now widely used and has greater speed and carrying capacity, with the added advantage of being able to deposit and spread the spoil at a controlled depth Where a long haul with the spoil is necessary, the self-propelled type of scraper is far superior. In the tractor-drawn type of scraper, carrying capacities of 4 to 12 cu yds are available Larger sizes are made in both tractor-drawn and self-propelled scrapers, and scrapers ranging from 6 to 12 yds. capacity have proved the most popular and useful for highway construction (Plate II, No 1)

Where the ground to be excavated has a hard crust, or is itself hard or of a rocky nature, the rooter, or ripper, is a most valuable tool, as it enables the ground to be broken up so that the scraper can handle it There are three types available—light, medium and heavy All three are tractor-drawn and operated by a similar power control unit as used with the scraper (Plate II, No 10)

Another essential piece of tractor-drawn equipment is the Bulldozer (Plate II, No 2) This machine can be operated by cable or hydraulic means, but the former is simpler and more common.

BLAW-KNOX, LTD.—(*contd*)

COMPACTING EQUIPMENT — For compaction of the soil which is to form the sub-grade of the highway, particularly where the scraper has been used to deposit the spoil in layers, the tractor-drawn Sheepsfoot Tamping Roller has established itself as a most efficient piece of equipment for this work. The pneumatic tyred multi-wheeled roller is also favoured by many engineers for following the sheepsfoot tamping roller.

CONCRETE MIXING MACHINERY —Where it has been decided to use concrete pavers or truckmixers, the plant will comprise steel storage bins and batch weighers. The storage capacity of the bins, which is usually 50 to 100 tons, will depend on conditions at site. The charging of the bins can be carried out by crawler-mounted cranes fitted with grab or dragline attachments. Bulk cement is an essential part of modern central batching or mixing plants. The cement can be elevated to the storage bin through a receiving hopper and screw conveyor and bucket elevator. Another method is to use one of the air activated types of equipment. The cement storage can either be incorporated in the main batching plant or located adjacent to it. This type of plant is the static type, but a more recent development is the mobile type, which is mounted on pneumatic-tyred wheels and can be readily transported from one site to another with little or no dismantling, and is capable of supplying 100 cu yds per hour, either into batch-carrying trucks or the charging hopper of mixers. (Plate II, No 6.)

CONCRETE SPREADING MACHINERY —In order to take full advantage of the speedy production of the concrete either by central mixing plant or paver, a mechanical concrete spreading machine is essential. One modern spreader will take care of the output of two 34E Pavers or their equivalent. The full mechanical traversing paddle type spreader is preferred, particularly if concrete of low water/cement ratio is to be handled.

CONCRETE FINISHING MACHINERY. To follow the spreading machine it is necessary to use a mechanical finisher. This machine can also provide the vibrated compaction so frequently called for in modern specifications. The most useful type of finisher is provided with a front oscillating strike-off plate to control the depth of the concrete to be compacted and finished. Behind this the vibrator unit is suspended. The finishing screed which follows the vibrating unit should also oscillate and strike off using the top of the roadforms as a guide. Low slump concrete with a water/cement ratio of 0 48 has successfully been vibrated to a depth of 12 in with this type of finishing machine.

ROADFORMS —To ensure the successful operation of the spreading and finishing machine, roadforms of robust construction should be provided. A secure and speedy setting of the roadforms can be ensured by using the self-aligning type way of mounting and dismounting. The 10S model is for single-way drive only but retains all the other features. Both machines driven from forward of the body comply with the law and include all stipulated accessories such as speedometer, mirror, etc. Lighting and starting equipment are also available.

E. BOYDELL & CO., LTD., MANCHESTER, 16

THE MUIR-HILL 10S & 10B DUMPERS —An important innovation of considerable interest to all dumper users, is the introduction of two entirely new machines to the Muir-Hill range. Users of these vehicles have always had to restrict their use to private property as those machines produced to date have not complied fully with the requirements of the law in relation to goods vehicles for use on the public highway. In the 10B model (Plate II, No 4), the driver's position is reversible, i e for use on the roads, the dumper is driven steering wheels first, while for use purely as a dumper, the seat and steering column is rotated and the machine is driven body first, retaining accurate placing and control of tipping.

The design of the rotating seat and steering column and the arrangement of the controls has been patented and affords complete control of all operations in either direction. The foot controls are duplicated and are so interlocked that their order remains unchanged, e.g., the clutch is on the left for either position of the seat. The gear lever, tipping and lever hand brake are between the driver and the engine and care has been taken to ensure that there are no obstructions in the

BRADLEY PULVERIZER COMPANY, LONDON, S W.1

Suppliers of the following well-known pulverizing mills: THE 24-in GRIFFIN MILL, THE IMPROVED 30-in GRIFFIN MILL, THE IMPROVED 40-in GIANT GRIFFIN MILL, and THE JUNIOR HERCULES MILL for grinding limestone, whinstone and other materials required for road Mastic Fillers. These mills are capable of pulverizing all classes of hard and refractory materials to any fineness between the range of 8 mesh to 240 mesh per linear inch sieve, such finenesses being given in a single operation without auxiliary sieving or separating. Capacities range from 5 cwt to 12 tons per hour, varying according to fineness and "grindability" of material.

W E BRAY & CO., LTD., ISLEWORTH

Hydraulically-operated bulldozers and angledozers ranging from 150 h p tractors weighing just under 22 tons to 22-h p tractors weighing about 3 tons. BRAY cable controlled dozers for all makes of track laying tractors. (Plate II, No 11.)

BRISTOWES MACHINERY, LTD., LONDON, N 18

Sprayers and heaters for tar and bitumen, sand dryers and mastic mixers, mounted on steel, solid rubber or pneumatic-tyred wheels. Capacities vary from the 50-gallon "HANDY" sprayer, vertical type, to the "CANTAR" all purpose sprayer, with a 2,500 gallon capacity, which can be fitted with patent steam heating elements for use as hot or cold sprayer. (Plate II, No 5.)

Other types of highway plant manufactured by this firm include tarmacadam, bitumastic and asphalt plants of varying capacities (tons per hour), granulators, and crushers, elevators and conveyors, screens, dryers and coolers, and mixers, etc. The BRISTOWE PATENT TARMACADAM MIXER is specially worth noting. It can be portable or stationary, and is available in 3 sizes: 4 ft diam 40/50 tons per day, 6 ft diam, 90/100 tons per day and 7 ft diam, 130/150 tons per day. (See also Manufacturers Data p 428.)

BRITISH JEFFREY-DIAMOND, LTD., WAKEFIELD

B J-D roll and swing hammer type crushers and swing hammer pulverizers, 8/10 sizes in each, used for the reduction of hard and friable materials of all classes to small sizes. Tests carried out in firm's laboratory on clients' own materials.

THE BRITISH ROTOTHERM CO., LTD., LONDON, S W 19

"ROTOTHERM MASTIC AND BITUMEN THERMOMETER, MODEL 41 —A portable dial-indicating thermometer designed for use in the preparation of asphalt, tar, bitumen, etc. Completely waterproof, extremely robust, and provided with a convenient handle. The "Rototherm" bi-metallic self-compensating multi-helix is incorporated. It is made with a dial 2¼ in or 4 in in diameter and has a standard range of 150/500 F. Models are also available for permanent attachment to storage and tar tanks and aggregate chutes.

ROBERT BROADBENT & SON, LTD., STALYBRIDGE

Stone and ore crushing plants designed to meet the requirements of mining companies and highway contractors, etc. All machines are fitted with a patent draw-back motion and patent oil bath. Plate II, No 3 illustrates the *Blake* stone breaker and ore crusher—suitable for breaking all kinds of stone, both for new road construction and for macadam surfacing.

BROOM & WADE, LTD., HIGH WYCOMBE

"BROOMWADE" PORTABLE AIR COMPRESSORS embody the well-known sleeve-valve compressor which was specially designed for portable sets. Its use makes possible relatively

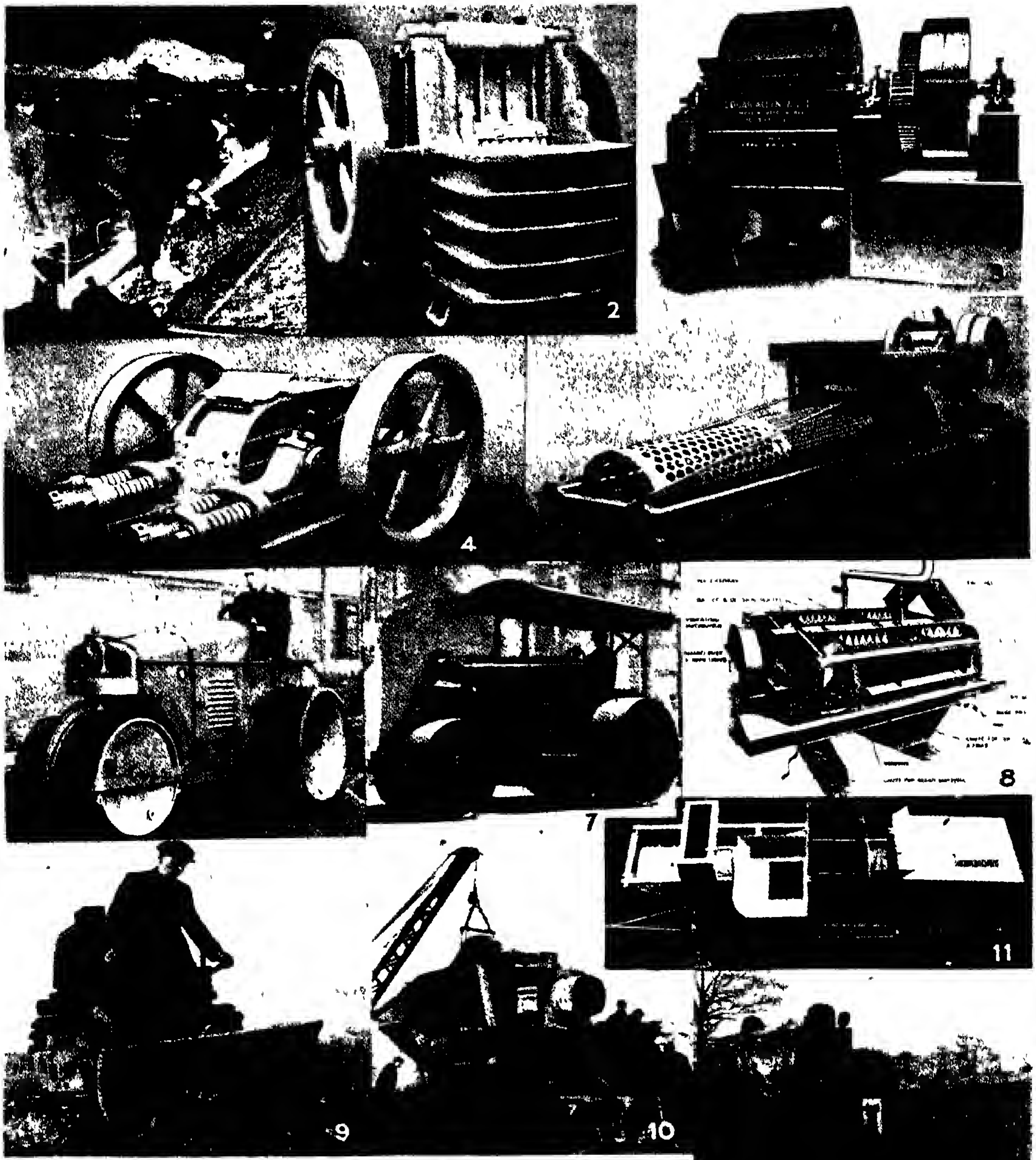


PLATE I

1, ALLAM VIBRATING TAMPER 2, 3, 4, 5 AND 8, EDGAR ALLEN STAG JAW CRUSHER, STAG BALL MILL, STAG CRUSHING ROLLS, ROTARY SCREEN, IMPERIAL SCRUBBER AND WASHER. 6, 7, 9 AND 12, AVELING-BARFORD G B ROLLER, G.D ROLLER, CALFDOZER AND TRENCH CUTTING MACHINE 10 AND 11, BENFORD B R 25 AND REGULUS MIXERS

BROOM & WADE, LTD. -(*contd*.)

high rotational speeds, resulting in complete plants of light weight and small dimensions which give very remarkable reliability with high efficiency and cool delivered air The compressors are of the single-stage water-cooled type The plants are being made at present in the three most popular sizes only to enable the maximum number of these to be produced to meet the tremendous demand

Type SV2, illustrated in Plate II, No 9, is fitted with a hand-operated clutch, but in all other cases, to enable the engine to be cranked by hand without turning the compressor, a simple centrifugal clutch is fitted which automatically takes up the drive on approaching load speed All plants are fitted with an automatic unloader which unloads the compressor when the maximum desired air receiver pressure is reached, and reduces engine speed when idling

The plants are completely self-contained and are provided with detachable sides of the lock-up type Standard chassis are fitted with steel or solid rubber-tyred wheels, but an increasing number are being supplied with pneumatic tyres

"BROOMWADE" PNEUMATIC TOOLS for highway engineering include road breakers, spades, picks, hand hammer drills, vibrators, backfill rammers and sump pumps All the percussive tools have a simple and highly efficient plate type distributing valve that is unaffected by dust and grit, and gives maximum performances with low air consumption

Breakers are made in three sizes to cover all types of duty, each size being designed to have the correct weight for its duty The RB660 gives 1450, the RB55, 1350, and the RB110, 1630 blows per minute Exhaust silencers can be fitted when required A pile-driving head is available for use with the two larger sizes for piles up to 3¾ in wide

Clay spades are available in two sizes CD4 weighs 20 lb with spade, gives 2,200 blows per min and consumes 25 cu ft free air per min at 80 lb pressure This tool is designed for overhead and horizontal work, and is well balanced and practically vibrationless CD40 is a heavier tool suitable for trench excavation It weighs 25¾ lb with spade, gives 1,800 blows per min and consumes 38 cu ft free air per min at 80 lb pressure Air connections ¾ or ½ in

Picks are made in three sizes, the CNP40 giving 1,800, the CNP50, 1,750 and the CNP60, 1,650 blows per minute and designed for smooth operation so as to minimize fatigue when used in awkward positions Air connections ¾ or ½ in

Hand hammer drills are available in sizes to cover every normal duty from plug and feather work, pop-holing and holes up to 30 ft deep in soft rock All are available in "Dry" "Blower" or "Wet" types Air connections ¾ in

Backfill rammer, type SR10, weight 50 lb Overall height 51 in. Strikes 350 blows per min Standard butt 4¾ in diam Air consumption 34 cu ft free air per min at 80 lb pressure It is easy to handle, self-supporting and consolidates backfill material to considerable depth. Air connections ½ in

Vibrators are of the simplest possible valveless design They are made in two sizes Type V45 weighs 8½ lb, gives 7,350 shocks per min and consumes 9 cu ft free air per min Type V60 weighs 17 lb, gives 5,400 shocks per min and consumes 14 cu ft of free air per min. Consumption of both types given at maximum working pressure of 65 lb per sq in

The "BROOMWADE" CONCRETE COMPACTOR embodies two type V45 and one type V60 vibrators mounted on a steel beam 8 ft long of 7 × 2 in channel section Tubular handles are fitted with balance weights attached to reduce vibrations transmitted to the operator (Plate II, No 8)

"BROOMWADE" DEWATERING GEAR —Submersible air-operated sump pumps driven by "BROOMWADE" multi-vane motors directly connected to the centrifugal pump impeller They are made in two sizes Type "3", suitable for high lifts, discharges 21 gals per min against a head of 100 ft, 96 gals. against 40 ft. head, and 140 gals against 5 ft head Type "5S" for greater outputs against heads up to 40 ft., discharges 189 gals per min against 5 ft. head, 160 gals against 20 ft head, and 97 gals. against 40 ft. head. To operate, the air is merely turned on and the pump lowered into the water

BUTTERS BROS & CO, LTD, GLASGOW, S 1

Manufacturers of cranes of all types for the use of highway engineers and civil engineering contractors

CARRIMORE SIX WHEELERS, LTD, LONDON, N 12

All steel constructed low-loading trailers, from 3 to 30 tons, for transporting excavators, pumping sets, and cable drums, etc (See also "Manufacturers' Data on Maintenance Equipment and Materials", page 428)

CATERPILLAR TRACTOR CO

See JACK OLDING & Co, LTD, page 346

C A V, LTD., LONDON, W 3

Electrical and fuel injection equipment for commercial vehicles, marine craft, aircraft and industrial engines

CHASESIDE ENGINEERING CO, LTD, ENFIELD, MIDDLESEX

Mobile mechanical shovels fitted with Fordson "Major" petrol engines and mounted on pneumatic tyres Made in two sizes, ½ and ¾ cu yd and used for picking up, loading, carrying and discharging all loose materials they are completely mobile and capable of moving at high speed Light excavators, standard type ⅜ cu yd capacity, used for handling consolidated materials, stripping over-burden and digging at the face Mobile cranes, 1-ton handy model, and 2-ton, also 1-ton coil or package stackers 2½ cu yd dumpers for speedy transport over poor ground All plant now available without permit

THE CLARMAC ENGINEERING CO, LTD, GLASGOW, C 4

"CLARMAC" TAR AND BITUMEN BOILERS are patent electric heaters for manufacture of macadam They are made in sizes from 60 to 6,000 gallon capacities, are automatic in operation and need no attendance Made to suit clients' requirements

"CLARMAC" OSCILLATING SCREENS are available for selecting and grading stone sizes for road-making purposes For drying stone prior to making macadam, CLARMAC ROTARY AND "STILL" TYPE STONE DRYERS are capable of handling very large quantities without making dust, these also are made to customers' requirements

CLARMAC BATCH TYPE TARMACADAM MIXERS, water jacketed and plain, are manufactured in standard sizes ¾, 1, 1½ cu yd capacity Temperature of both stone and bitumen can be controlled when mixing macadam CLARMAC STONE GRADERS have a variable "cut-off" to permit grading of stone prior to the manufacture of macadam They have automatic operation in handling stone from storage to mixing plant, 36 in is the standard size

Heavy plate type CLARMAC CRUSHER FEEDERS enable heavy stones to be fed to a crushing machine, and can be fitted with infinitely variable speed gears if required.

CLIMAX ROCK DRILL & ENGINEERING WORKS, LTD, LONDON, E C 2

All types of Pneumatic tools, rock drills, paving breakers, back fill rammers, wagon drills, trench pumps and portable air compressors

GEO COHEN, SONS & CO, LTD., LONDON, N W.10

"SILVER CIRCLE" brand tools for highway contractors, and protective clothing Contractors' plant hire service for all types of equipment

THOS. COLEMAN & SONS, LTD, DERBY

Used in the treatment of road surfaces the "FLAPPER" SPRAYING MACHINE for tar and bitumen gives uniform distribution and rapidity of operation Available in 250, 500, 800 and 1,000 gallon capacities The "ARCH" BOILER for tar, pitch or bitumen is used for the rapid heating of materials for road work and is made in various sizes with capacities from 50 to 500 gallons

For gritting roads the "VEE" GRITTER is used in conjunction

THOS. COLEMAN & SONS, LTD.—(*contd*)

with the "FLAPPER" tar sprayer, it has a 5-ton capacity and applies a covering of grit while the tar is hot (See also "Manufacturers' Data on Maintenance Equipment and Materials", p 428)

COMMER CARS, LTD, LUTON

A wide range of "SUPERPOISE" lorries is available for transportation of road materials All models from the 2-3-ton to the 4-5-ton incorporate the patented "DIALFLEX" system of mounting which obviates the tendency of the chassis frame to flex when driven over rough ground The "COMMER-HANDS" 6 and 8-ton articulated tractor-trailers with automatic coupling gear are also ideal for transporting heavy loads These models are equipped with the Karrier "J" type automatic detachable coupling gear and retractable trailer fore-carriage, which formed such a valuable feature of the original Karrier "Mechanical Horse" (See also under Karrier Motors Ltd)

THE CONCRETE PUMP CO, LTD, LONDON, W 8

"PUMPCRETE" CONCRETE PUMP transports by pipeline plastic concrete of high strength, great density and perfect uniformity from the mixer into place It does not interfere with building operations and reaches many otherwise inaccessible places, maintaining its output at any distance within its range There are two sizes of "PUMPCRETE", type PC3 with a capacity of 20–24 cu yd per hour and type PC4 with 8 10 cu yd. capacity per hour The complete machine is mounted on a heavy wrought-iron under-bed frame, with room for the prime mover No special foundations are required for the concrete pump (Plate II No 12, shows the PC4 Pump)

W. B DICK & CO, LTD, LONDON, S W 1

"Ilo" lubricating oils and greases for concrete mixers, compressors, excavators, road rollers, cranes, and all mechanical appliances used by highway engineers and public works contractors

DOLLERY & PALMER (PNEUMATIC TOOLS), LTD, LONDON, S W 1

For concrete breaking, the "CHAMPION" and "LITTLE CHAMPION" pneumatic breakers, 77 lb and 39 lb respectively, are very powerful, and have practically no recoil Pneumatic claydiggers of the ACD range, are available in three standard sizes 27, 29½ and 37 lb.; these are excellent for trenching work Air-hose and accessories including automatic valves which take the place of aircocks and save air consumption

W H. DORMAN & CO., LTD., STAFFORD

Manufacturers of a wide range of diesel engines for driving all classes of industrial machinery and road-making plant Horse-power ratings vary from 8 b h p to 120 b h p

THE DREWRY CAR CO, LTD, LONDON, E C 2

"DREWRY" locomotives and rail tractors are available in sizes from 10 to 200 h p., with petrol or diesel oil engines, ranging from 2½ to 30 tons in weight Used extensively in quarries and mines, etc, and by contractors and estate owners

THE EAST DEREHAM FOUNDRY, LTD, DEREHAM

The EDF TENDER for fuel or water is an all-welded cylindrical construction and its use reduces time and labour to a minimum In one operation, without any waste, 250 gallons can be carried to points difficult of access, and the necessity of carrying cans for refuelling and re-watering is obviated

EDDISON STEAM ROLLING CO, LTD., DORCHESTER

Hirers of steam, diesel and petrol road rollers from 2½-ton petrol driven to 6 to 14-ton steam rollers, which are fitted with scarifiers, for surfacing and construction of roads. Numerous depots exist throughout the country, and the heaviest class of repairs to engines and boilers can be handled at the Dorchester Works.

ENGLISH TOOLS, LTD, WIGAN

Manufacturers of shovels, forks and rakes, etc, for road and general contractors use

ERF, LTD, SANDBACH

4-wheel vehicles fitted with hydraulic end or three-way tipping bodies of 7½-ton (6 cu yd capacity) Models C14, C15, and C16 are powered with 4, 5 and 6-cylinder oil engines respectively.

FIELDING & PLATT, LTD, GLOUCESTER

Hydraulic three-mould presses, 400-ton power, for concrete paving slabs, maximum size 3 ft × 2 ft 2½ in thick, and kerbs in accordance with B S dimensions Installations are supplied complete with vacuum crane, mixer, hopper, jack-lift trolleys and hydraulic-pressure water plant for powering the press Simplicity of operation and high-speed production of slabs of great density an important advantage

THOS. FIRTH & JOHN BROWN, LTD, SHEFFIELD

All types and sizes of steel grader blades ("FIRTHAO"), scarifier tines, road wedges, vehicle springs, tool steels for pneumatic drills, etc, high speed steel twist drills ("SPEEDICUT") and all forms of engineers' tools for road levelling and road surface breaking purposes

FODENS, LTD, SANDBACH

The D G 5–7-ton diesel-type hydraulic 3-way tipper, fitted with Gardener 5-cyl, 5 L W Oil engine, has a capacity of 6 cu yd and can be supplied with a special five-speed super low-gear box (Plate III, No 9)

THE GLOBE PNEUMATIC ENG CO., LTD, ROMFORD

All types of pneumatic tools for highway work Of special note is the GB75 CONCRETE BREAKER which has been standardized by the War Office for service units (Plate II, No 7) For lighter demolition work the L 5 PNEUMATIC PICK AND SPADE is widely used by contractors

GOODWIN, BARSBY & CO, LTD, LEICESTER

"GOOD-WIN" road-making plant has actually been in service for more than half a century, during this time, tremendous developments have taken place

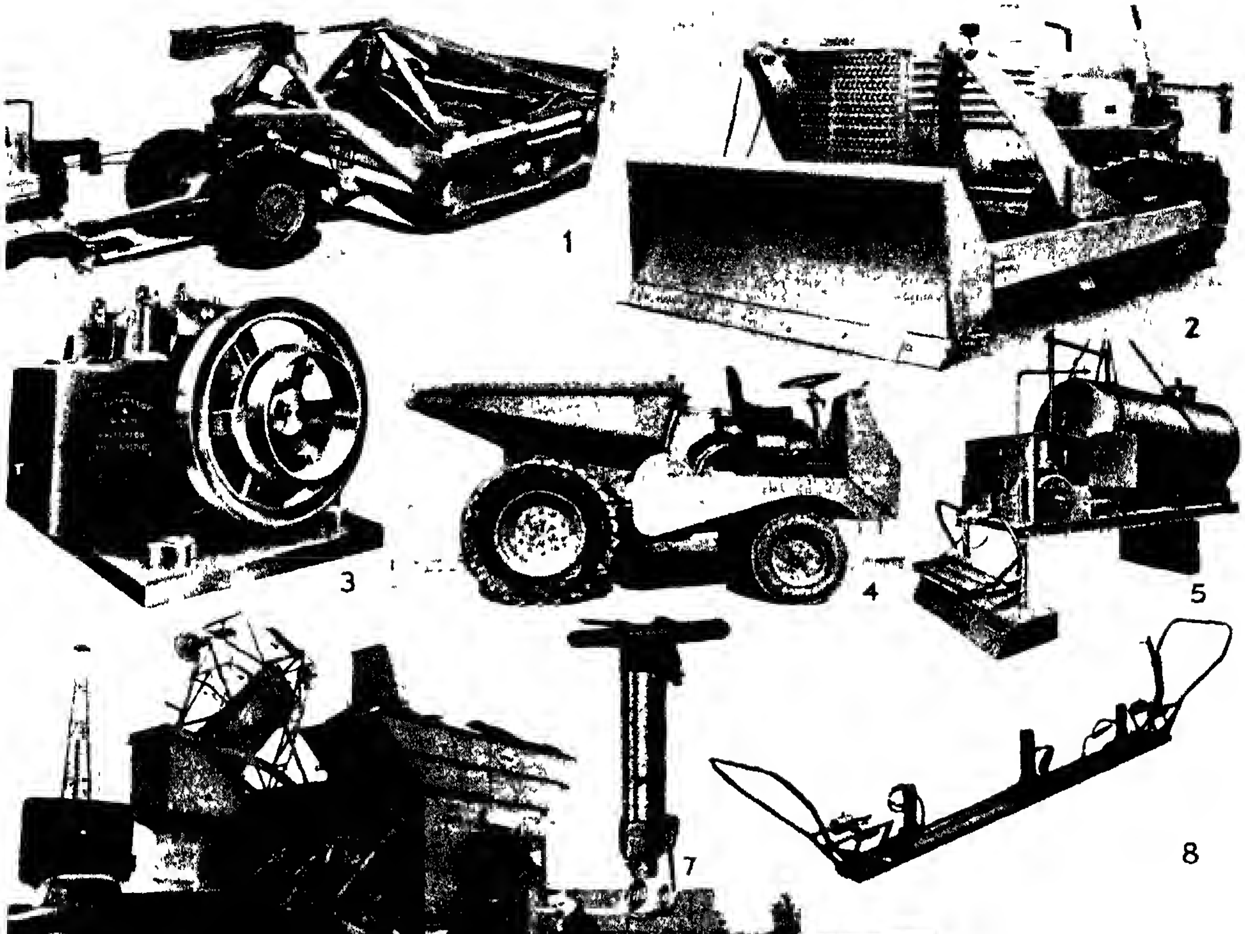
While stonebreaking machines were the first specialized Good-win productions, the present range of specialities cover a much wider field The demand for larger primary breakers to reduce quarrying costs has been met by the improved design of the well-known Blake type stone-breaker The Good-win range in this class is built in steel or cast iron and ranges from machines with outputs from 10 to 100 t p h

The most recent improvement has been the fitting of automatic lubrication The modern 42 30 in steel Blake with automatic lubrication is illustrated in Plate IV, No. 6

The Good-win range of secondary crushers includes the Patent ACME Single Toggle machine including Patent ACME Granulator, AJAX Impact Breaker and GOOD-WIN Fine Crushing Rolls Jaw Crushers produce an excellent sample of road material Impact breakers are particularly satisfactory on gravel and the use of rolls is generally confined to the production of the smaller-sized material

This increasing demand for chippings has created new problems in rural areas of scattered road mileage but modern portable machines with breaker and granulator combined have now largely overcome the difficulty The Good-win combined CORNWALL outfit (Plate III, No 4), supplies a complete portable stone-breaking and/or granulator outfit The machine can be driven and drawn by oil tractor and being completely self-contained can be put to work in a very short time

Goodwin Plant includes a wide range of grading, screening and washing machinery from the simple rotary screen to the multiple deck vibrating screen, but the inclusion of



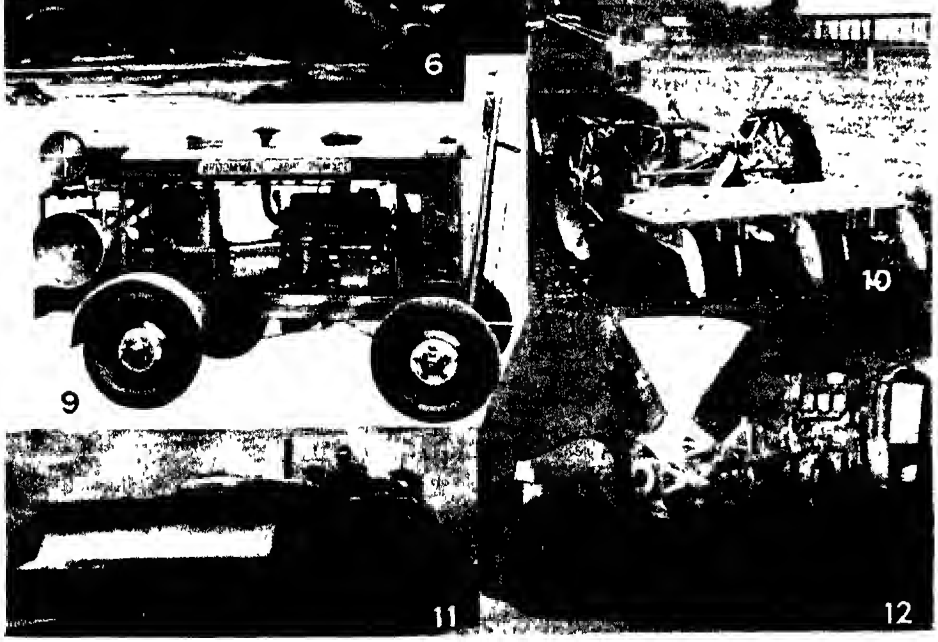


PLATE II

1, 2, 6 AND 10, BLAW-KNOX 12-YD SCRAPER BULLDOZER, CONCRETE MIXING PLANT AND LIGHT RIPPER 3, ROBERT BROADBENT "BLAKE" STONE BREAKER 4, E BOYDELL MUIR-HILL 10B DUMPER 5, BRISTOWES MACHINERY "CANTAR" ALL-PURPOSE SPRAYER 7, GLOBE PNEUMATIC CONCRETE BREAKER NO 1 8 AND 9, BROOMWADE CONCRETE COMPACTOR AND SV2 AIR-COMPRESSOR 11, W E BRAY DOZER. 12, CONCRETE PUMP CO PC4 CONCRETE PUMP

GOODWIN, BARSBY & CO, LTD—(*contd*)

washing in a specification has brought into being various classes of machinery to deal with the problem

Many years of experience lie behind Good-win washing and screening plants which are designed and built for outputs varying from 5 to 120 t p h, from all portable machines to installations covering several acres of ground

Modern development in the use of hot tar and bitumen mixtures has called for efficient drying and mixing of aggregate and the GOOD-WIN PYRUS DRYER (Plate III, No. 5), either coke or oil fired, meets this demand The machine in general principle has been in use for many years but most up-to-date models include the results of recent research in this direction

Batching, measuring and mixing has also been studied carefully, and the result embodied in modern plant design Plate III, No 8 illustrates the GOOD-WIN double shaft paddle mixer

Both portable and fixed combined plants are built in various sizes and types to suit local conditions The arrangement and efficiency of the individual machines is the same throughout the range

Asphalt is catered for in the same way, but installations are usually of a portable or semi-portable nature due to the quick setting of the mix, and provision is also made for accurately weighing each item of the mix

The use of a number of machines in combination calls for an efficient linking of these by means of conveyors and elevators, automatic feeders and similar material-handling plant The Good-win range covers all these features and in design they are combined to form the complete installation

Concrete mixing is also covered by the GOOD-WIN and MASTER-MIXERS which provide a complete range of sizes and types to suit all requirements, from the smaller portable machine towed behind a light lorry to the combined batching plant for the production of mass concrete

The most recent model produced is the TALL-MASTER trailer mixer which provides a machine of high output with extreme mobility

THE GOODYEAR TYRE & RUBBER CO (GREAT BRITAIN), LTD, WOLVERHAMPTON

Giant pneumatic tyres with "SURE GRIP" tread in a range of popular sizes for off the road haulage, capable of moving heavy loads in soft ground Tyres for low-loading vehicles with grooved or all weather tread. A complete range of pneumatic tyres for road haulage work with maximum traction and non-skid qualities. Earth moving tyres with rib, grooved, "ALL-WEATHER" or "SURE-GRIP" treads, in a wide range of sizes, with maximum traction and good steering ability for dumpers and scrapers, etc

THOS GREEN & SON, LTD., LEEDS

"GRIFFIN" petrol and diesel-engined three-roll machines, various types from 2 to 12 tons, for all classes of light, medium and heavy rolling. In types D R L 5 to 6½ tons and D R M 7 to 12 tons, the rolls are arranged for water ballast giving a weight variation of approximately 1 ton Scarifiers can be fitted.

N. GREENING & SONS, LTD, WARRINGTON

Woven wire and perforated plates of all types used in the production of road stone and concrete aggregates "AGATE" steel vibrating screen cloths. All apertures $\frac{1}{16}$ to 4 in square and also slot apertures Testing Sieves to B.S S. 410 1943. Wedge Wire and Profile Bar Screens

JOHN A. GREY & PARTNERS, LTD., LONDON, S.W.1

Distributors for Dempster-Dumpster Haulage Equipment, Schramm Air Compressors, Master Turn-a-Trowels and Vibratory Screeds, Gruendler Crushers and Pulverizers, Hughes-Keenan Roustabout Cranes, and Bay City Equipment.

The DEMPSTER-DUMPSTER SYSTEM allows one truck to do the work of five, speedily and economically Buckets, detachable bodies and hoisting units are made in a variety of designs The hoisting unit picks up a loaded body of any size, places it in the carrying position and transports it to the disposal point All three operations controlled entirely from the driver's cab

THE SCHRAMM AIR COMPRESSOR is a streamlined, smooth-running time and labour saving diesel-driven machine Standard equipment includes electric self-starter ensuring safety for the operator, and force-feed lubrication in all moving parts.

For accurate strike off and compaction of concrete in one operation the MASTER VIBRATORY FINISHING SCREED finishes up to 6,000 sq ft per hour

THE HUGHES-KEENAN ROUSTABOUT CRANES are fast moving, easy to handle cranes which cut down time, man-power and cost The machine is small and compact and can work in narrow spaces and at awkward corners

GRUENDLER STATIONARY, SEMI-PORTABLE AND PORTABLE CRUSHERS employ the swing hammer principle, as well as the jaw principle Sizes range from the small portable roadside plants to modern models employed in large cement mills.

BAY CITY convertible crawler and pneumatic tyre-mounted shovels, cranes draglines and hoes, trailers and dragline buckets are available in a wide range of capacities to meet the needs of all types of excavation and building projects

GUY MOTORS, LTD, LONDON, W2

"VIXEN" chassis, 4-ton lorry used as tipping wagon, truck, tractor or tower wagon Wheel-base 10 ft 7¾ in, 13 ft 1¼ in, or 8 ft 6 in "WOLF" chassis 2x3-ton lorry with 10 ft 6 in or 13 ft wheel-base for tipping wagon or truck

HADFIELDS, LTD, SHEFFIELD

Have for many years specialized in the production of stone-breaking and granulating plant and their range of double and single toggle machines has won high renown

They are of steel construction throughout ensuring the utmost strength with minimum weight Crushing jaws and certain other parts are constructed of "ERA" Manganese Steel which resists the abrasive action of hard stone and ores. A centrally-operated mechanical system of lubrication for all important bearings is standard for all crushers above a certain size and can be applied to smaller machines as extra equipment This system, which indefinitely extends the wearing life of the bearings, functions only while the machines are in actual operation and is far more economical in oil than hand lubrication

The range extends from small machines conveniently mounted on travelling chassis with suitable screens, etc for road making and concrete construction contracts, to large stationary breakers having 72 × 48 in. receiving openings and capable of outputs up to 300 tons per hour in hard limestone Plate III, No 3 illustrates a 24 × 13 in Hadfield Double Toggle Breaker.

A large range of spare parts is maintained and prompt delivery made

A feature of the Hadfield service is prompt delivery of spare parts of which large stocks for all sizes of crushers are constantly maintained

HARDYPICK, LIMITED, SHEFFIELD, 8

Can supply hand-power boring appliances or fully contained power boring outfits for dealing with all kinds of strata HARDYS RIPPERS AND PNEUMATIC DIGGERS (Plate III, Nos. 6 and 7) are equipped with a patent flap valve which having unequal bearing surfaces is always seated, ensuring positive action A perforated exhaust chamber is fitted to each machine which acts as a self-contained silencer They are used for breaking concrete, sandstone, metalled roads, etc. Spades can also be supplied for cutting clay or shale, and other tools, including asphalt cutters, chisel points, etc., are available to

HARDYPICK, LIMITED—(*contd*)

specification Machines are of simple streamlined construction, and can be operated horizontally or vertically

"HARDY'S" HAND AUGER for boring holes in earth and soft clay, sub-soil investigation to a depth of 30 feet Made in eight sizes from 3 to 10 in diameters, the blades are made from special quality steel suitably bevelled, hardened and tempered

HEATHS (ECCLES), LTD, PATRICROFT, LANCS

"PIONEER" portable equipment for industrial light, narrow gauge railways, available in a wide range of standard types up to 24 in gauge (other gauges to order) "PIONEER" steel wheelbarrows and concrete carts for moving concrete, earth and semi-liquid or liquid substances

JOHN M HENDERSON & CO, LTD, ABERDEEN

Manufacturers of aerial cableways and ropeways, aerial cableway dragline excavators, cable drag scrapers, cranes of all types, crushing and grinding mills and all types of mechanical handling and transporting plant to customers' drawings

F. C HIBBERD & CO, LTD, LONDON, SW1

"PLANET" DIESEL LOCOMOTIVES, 10 to 75 h p for Decauville track, used in public works construction, etc "PLANET" RUBBER-TYRED TRUCKS AND TRACTORS 10 h p petrol and 16 h p diesel, for short hauls in congested areas

HOLMAN BROS, LTD, CAMBORNE

PNEUMATIC CONCRETE COMPACTORS, ideal for speedy and efficient concrete road construction They introduce a new principle in the compaction of concrete, consolidating dry mixes to full depth quickly, efficiently Blows of hammers are transmitted direct to concrete without energy being lost by being absorbed in screed Lengths other than the standard 12 ft can be cambered if necessary For truly smooth and accurate finish the compactor should be followed by the Holman Vibrated Finishing Screed (Plate III, No 12)

PNEUMATIC RAMMERS provide easy and rapid means of packing loose material, consolidating backfill, making concrete blocks, preparing moulds, etc Available in various sizes with different shaped butts and peins

Hard hitting HOLMAN ROAD RIPPERS for tearing up road surfaces and foundations, have high penetration speed and low air consumption Silencers can be fitted to all models (Plate III, No 2)

THE HOLMAN ROTOPUMP is a sturdy compressed air-operated pump for dealing with water, oil or other liquids up to moderately thick sludge

COMPRESSORS of various types are included in the Holman range, either air-cooled or water-cooled two stage machines with high output The portable air compressors are of the same basic principles as the two stationary models, but with water-cooled cylinders and an air-cooled intercooler The TRACTAIR unit is composed of a Holman two-stage air-cooled air compressor mounted on a Fordson Major Tractor and is capable of operating, at full pressure, a heavy road ripper or a 40-lb Handril or equivalent pneumatic plant, without affecting the towing capacity of the tractor (Plate III, No 11)

ROBERT HUDSON, LTD, LEEDS

Manufacturers of light railway equipment for highway and municipal engineering application

THE HYDRAULIC ENGINEERING CO., LTD., CHESTER

The "MANGNALL THRUST BORER" is used extensively for laying pipes and cables across streets and roads and obviates the necessity for trenching. The borer consists of a hydraulic propelled crosshead working on parallel slides, and the high pressure hydraulic pump operated by hand is of the double-acting differential type Borings are usually made horizontally but can be made vertically or on any inclined plane

INTERNATIONAL HARVESTER COMPANY OF GT. BRITAIN, LTD, LONDON, E C 1

INTERNATIONAL Motor Trucks, 15 cwt /12 tons payloads, for all classes of haulage. INTERNATIONAL "TRACTRACTORS" for earth moving, logging and forestry haulage and levelling work. Four sizes, 30 DHP, 39 DHP, 54 DHP and 70 DHP INTERNATIONAL Stationary Power Units, 39 BHP (Diesel) 156 lb-ft torque

C H JOHNSON (MACHINERY), LTD, STOCKPORT

IMMERSION TYPE CONCRETE VIBRATOR generates powerful vibration which is confined to the needle thus ensuring long life of motor and imposing no strain on the operator It is totally enclosed and impervious to moisture, all mechanical parts are greased and sealed for life Capacity 50 to 70 cu yd per 8 working hours

THE "SUPER" VIBRATING HAND SCREED for compaction of 10-in deep road made of "no-slump" concrete The machine is capable of handling 130 to 150 cu yd or 900 sq yd of 6-in concrete per day and the vibrator can be fixed to either a straight or cambered screed, and can be used on all standard types of road forms and for all types of cambered and hanging roads, intersections, cross-roads and roundabouts, etc (Plate III, No 10)

THE JOHNSON "SUPER" 240-lb POWER RAMMER has a magnesium alloy head, a new type of exhaust valve dispenses entirely with springs and obviates the trouble of sticking through over-oiling The base is cast in one piece with a large filling orifice (Plate IV, No 2)

THE JOHNSON V8 COMPRESSOR, MODEL P65 consists of a composite engine-compressor unit, utilizing the Ford V8 30-h p engine One bank of 4 cylinders is converted to act as compressor, the other cylinder bank being the power unit The compressor head is water-cooled and the delivered air passes through water-jacketed passages in the cylinder block, obviating the use of an after cooler (Plate IV, No 1)

JOHNSTON BROS (CONTRACTORS), LTD, LONDON, E C.3

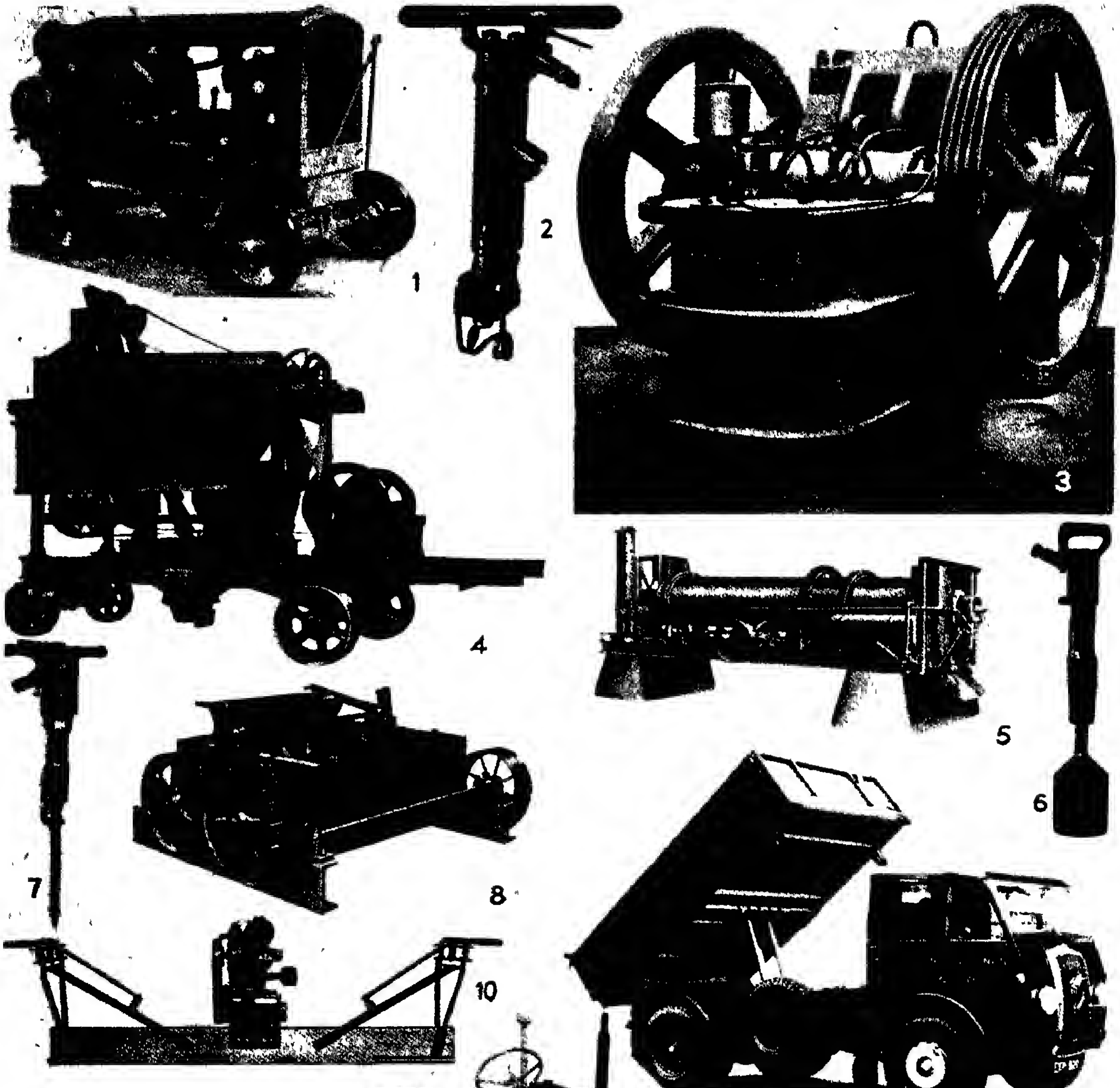
Manufacturers and suppliers of all types of road machinery for construction, repair and maintenance of highways

The "SUPERDOME" (Plate IV, No 4) for heating and spraying tar and bitumen, is a complete trailer boiler unit manufactured to Ministry of Transport requirements and can be hauled at ordinary traffic speeds The machines are supplied equipped for either coal or oil firing, and accessories include thermometer, tools, spray pipes and nozzles, the units are mounted on steel wheels with roller bearings and pneumatic tyres

The JOHNSTON SUPERMOBILE DRYER AND MIXER is a portable unit for sand asphalt, bituminous or tarmacadam On one chassis, which can be equipped with either solid or pneumatic tyres, is provided the dryer, the mixer, the storage hopper, two feed elevators, automatic bitumen measure, bitumen pump and all pipe connections, the operating platform and all operating mechanism, which can be transported from one working point to another without any dismantling The capacity of this unit is up to 5 tons per hour of sand asphalt and up to 10 tons per hour of tarmacadam

The JOHNSTON DOUBLE ACTOR COLD EMULSION SPRAYER unit entirely dispenses with compressed air and the complications in the use thereof with cold emulsions and is supplied instead with a special all-steel double acting pump, hand-operated which gives a continuity of action and a uniformity of spray The complete unit is on steel wheels, or alternatively rubber-shod or pneumatic tyres to user's option

JOHNSTON GRITTERS for surface dressing range from the small hand-operated machine of 5 to 6 cu ft capacity up to the large 6-ton low-loading four-wheeled unit. Every gritter is fitted with the exclusive final brush distribution through the hopper mouth to the road surface This brush distribution is adjustable according to the quantity and size of material being dealt with, and possesses the great advantage that



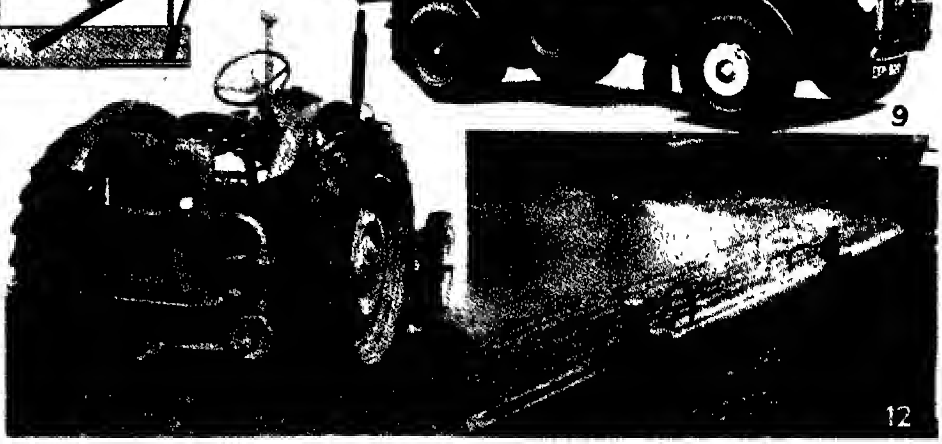


PLATE III

1, Atlas-Diesel MK 35D Air Compressor 2, 11 and 12, Holman Bros Road Ripper, "Tractair" Compressor and Concrete Compactor 3, Hadfield's Double Toggle Breaker 4, 5 and 8, Goodwin-Barsby "Cornwall" Stone-breaking Plant, "Pyrus" Dryer, and Double Shaft Paddle Mixer. 6 and 7 Hardypick Pneumatic Digger and Ripper. 9, Foden's D G Tipper. 10, C. H. Johnson's "Super" Vibrating Hand Screed.

JOHNSTON BROS (CONTRACTORS), LTD —(contd)

large stones or other foreign bodies accidentally getting into the machine do not affect the continuity of discharge.

The "EVERHOT" SMOOTHING IRON is an extremely efficient and convenient tool for ironing the bitumen joints between concrete slabs in roadways, runways and the like The iron is oil-fired, so arranged that the handle forms the fuel reservoir with the pump for generating pressure at the top of the handle with the burner mounted in such a manner that it fires directly into the hollow interior of the iron (See also "Manufacturers' Data on Maintenance and Equipment", p 429)

K & L. STEEL FOUNDERS, LTD., LETCHWORTH, HERTS

The JONES "SUPER 22" is a popular 2-ton capacity, fully mobile, diesel engine driven crane It can be fitted with a cantilever jib for restricted headroom, or lattice strut jib for high lifts Chassis can be mounted on either pneumatic or solid rubber tyres Travelling speed up to 4 miles per hour

The JONES "SUPER 40" is a 3-ton capacity, fully mobile, diesel engine driven crane Standard jib 24-ft long Longer jibs supplied to order Chassis can be mounted on either solid rubber tyres, heavy duty pneumatics, or crawler track All motions—hoisting, travelling, slewing and derricking are power operated

The JONES "SUPER 100" is a 5-ton capacity, heavy duty, rail shunting crane with a lifting capacity of 5 tons at 16 feet radius, and a shunting capacity of 150 tons

It is powered by high speed radiator cooled, diesel engine, and all motions hoisting, travelling, slewing, and derricking are power operated The JONES "Super 100" is a high grade engineering job suitable for railways, docks, harbours and large works

KARRIER MOTORS, LTD, LUTON

MODEL "CK3" 3–4-ton lorry is a modernized version of the Karrier three-tonner, it includes a more powerful engine developing 80 b h p and is useful for all types of road haulage

The "BANTAM" two-tonner is an extremely mobile four wheeler adaptable either as a van, lorry or tipper The "BANTAM" is also available as a tractor for use in connection with super-imposed trailers, automatically coupled and capable of carrying payloads up to 5 tons (See "Cleansing of Roads", p 422)

THE LEAD WOOL CO, LTD, SNODLAND, KENT

Two-stage compressors in various sizes and capacities on solid rubber or pneumatic tyres Supplied complete with all pneumatic tools and appliances required for breaking-up roads, rock drilling, clay digging, concrete breaking and tamping, etc

R. G LE TOURNEAU INC (U S.A)

See JACK OLDING & Co, LTD, p 346

LINER CONCRETE MACHINERY CO, LONDON, S W.1

Designers and manufacturers of concrete and contracting machinery The most noteworthy machines in the liner range are the "JUNIOR" No HOPPER MIXER which is available in 5/3½ and 7/5 sizes with two or four wheels "THE CLOVERLEAF" a tilting-drum mixer made in 5/3½, 7/5, 8½/6 and 10/7 sizes. The specially-designed "Cloverleaf" drum ensures perfect mixing and the machine incorporates a novel hopper control. The LINER CLOSED DRUM MIXER is a sturdily built mixer which is fast in operation and with self-cleaning hopper and quick discharge from drum, made in 8½/6, 10/7 and 14/10 sizes

Made in 6 sizes from 2 ft 10 in to 7 ft 3 in diameter pans, the "ROLPANIT" is excellent for mixing sand-lime mortar, sand-cement mortar, plaster, semi-dry concrete, etc The machine is easily portable and economical

The "CUMFLOW" mixer is capable of efficiently dealing with every type of mix, dry, plastic or wet, lean, rich, fine or coarse, light or heavy A half minute mix will give maximum strength

LINER BREAKERS are made in two types, light and heavy stone and in many sizes from 8×5 in to 20×10 in Can be supplied fixed or portable and with or without screening attachment.

Other types of liner equipment are diaphragm pumps, hoists and elevators and wheelbarrows and tipcarts

J & H McLAREN, LTD, LEEDS, 10

Vertical four-cycle solid injection diesel engines The LMR type is built in sizes of 2, 4, 5 and 6-cylinder, output per cylinder is 12 b h p at 1,250 r p m per 12-hour rating Type MR, available in sizes of 2, 3, 4, 5, 6 and 8-cylinders, output per cycle being 22 b h p at 1,000 r p m per 12-hour rating These engines are for use as power units in excavators, road rollers, portable compressors, diesel locomotives, and electric generator and pump drives, etc

H. R MARSDEN, LTD, LEEDS, 11

All types of road-making plant including stone-breakers, ore crushers, jaw and hammer type granulators, high speed crushing rolls, pulverizers, grinding mills, rotary and vibrating screens, elevators and conveyors, complete stone-breaking and screening plants, gravel washing and screening plants, dryers, tarmacadam and asphalt plants, etc

MARSHALL SONS & CO, LTD, GAINSBOROUGH

MARSHALL TYPE "RD" DIESEL ROAD ROLLERS were first introduced in 1931, and the weight range is from 6 to 14 tons Special features are the centrally-placed multi-cylinder engine and double gear drive to hind rolls with differential incorporated in the gearbox with locking device on the footplate Front and rear axles are rigid and the steerage is enclosed in the front head A sliding scarifier is fitted to rear of the roller

The gears are machine-cut and the splined shafts run in ball or roller bearings All of the gears are below oil level and run in an oil bath Smooth reverse action is obtained by means of the large diameter cone type clutches and the expanding type footbrake holds the roller whether it is in or out of gear

Water sprayers, power pulley, power steering, Sliding Scarifiers and hand pump with hose for filling the sprayer tank can be added to this type of Roller Awning with side and end curtains, also water ballast rolls are standard equipment

The "RD" Roller can be constructed as a "Three axle Roller" by the addition of a central ironer roll hydraulically-operated, and an air compressor with road breaker attachment has been fitted to meet special requirements. (Plate IV, No 8)

MARSHALL TYPE "TSP" DIESEL ROAD ROLLERS comprise a range of Rollers simple in design but sturdy in construction Built in sizes 6 to 11 tons these rollers are fitted with a 4-cylinder Perkins diesel engine with electric starter, and the construction of the gearbox assembly is generally in accordance with the standard MARSHALL design

A Vulcan-Sinclair hydraulic coupling can be fitted if desired, and the normal additional equipment such as water sprayers, hand pump and hose, also sliding type scarifier can be supplied if required

The SLIDING SCARIFIER has four working positions across the rear of the roller, thus the roller can always face downhill when scarifying and the full width of narrow roads can be pulled up (Plate IV, No 5)

MARTIN, BLACK & CO. (WIRE ROPES), LTD, COATBRIDGE

Wire ropes manufactured in any construction and quality ranging in size from the very fine cords used for aircraft, to the mammoth ropes used for salvage, dock gates and slipways. Each rope is composed of a varying number of wires carefully balanced in relation to each other

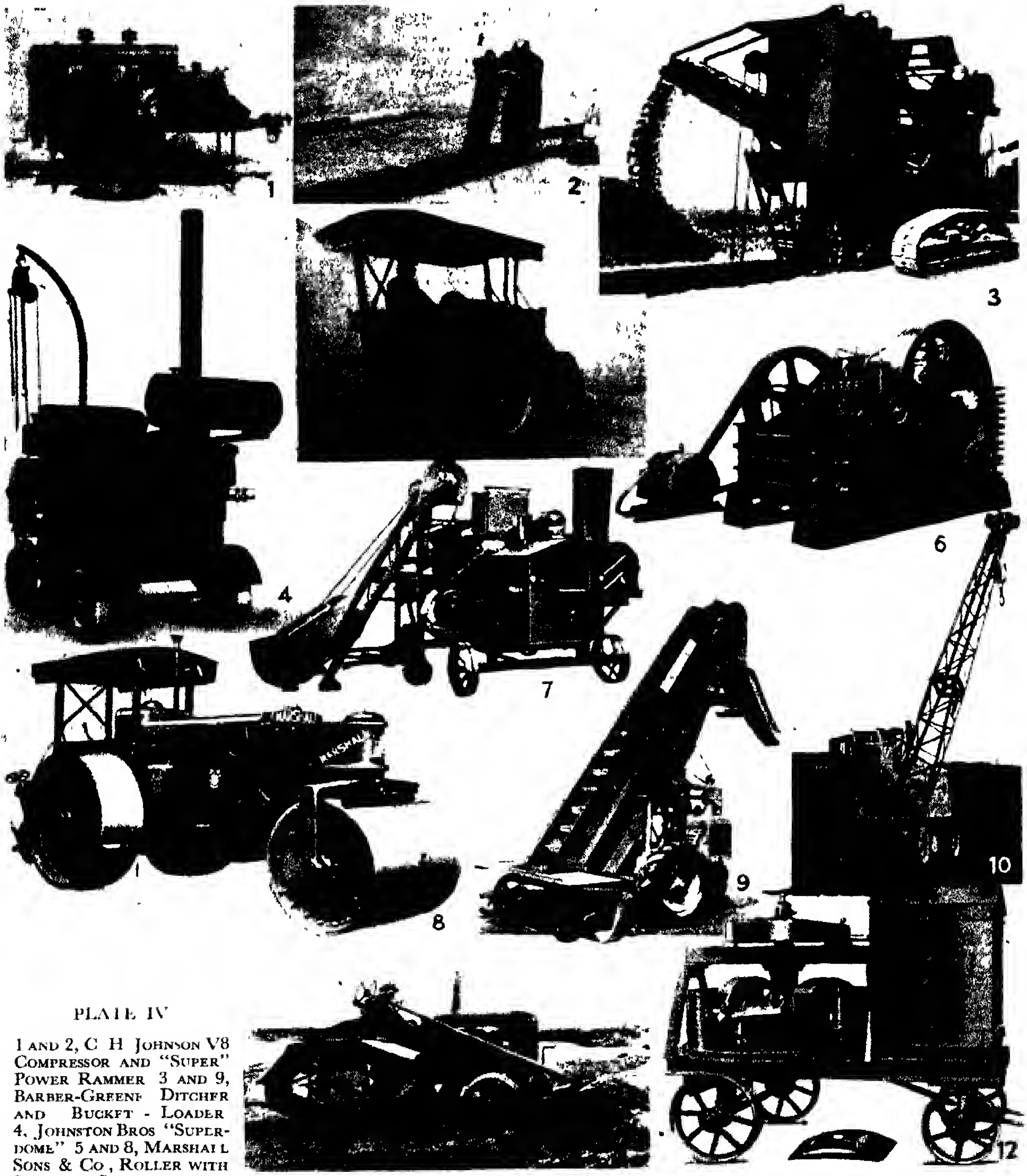


PLATE IV

1 and 2, C H Johnson V8 Compressor and "Super" Power Rammer 3 and 9, Barber-Greene Ditcher and Bucket - Loader 4, Johnston Bros "Super-dome" 5 and 8, Marshall Sons & Co, Roller with Sliding Scarifier and "R D." Roller. 6, Goodwin-Barsby "Blake" Stone-breaker 7 and 12, Millars' Machinery Highways Dryer and Mixer, and Roller Pan Mixer. 10, R H Neal "NM" Mobile Crane. 11, Geo Monro "Muledozer".

MAUDSLAY MOTOR CO., LTD., ALCESTER

A range of motor lorries for all types of load carrying. The MILITANT MARK III has a short wheel-base tipping chassis and is equipped with a Gardner 4 L W heavy-oil four-cylinder engine.

The MOGUL MARK III, a solo, 2 axle, four-wheel load carrier has a 6-cylinder diesel or petrol engine, and an approximate payload of 7½ tons. The MUSTANG solo 3 axle 6 wheel model has a payload capacity of 10 tons, and a 6-cylinder diesel engine. The MAHARANEE short wheel-base tractor unit for articulated trailer work, is equipped with a 6-cylinder diesel engine, and an approximate payload of 11 to 13 tons. The 12 to 13-ton MAHARAJAH has a 6-wheel rigid base and a 6-cylinder diesel engine. The MERITOR, 14 to 15-ton load carrier, on an 8-wheel rigid base with a 6-cylinder diesel engine. All models are equipped with a coachbuilt driving cab, flat loading platform, with 18 or 24-in. dropped sides and tail boards.

MILLARS' MACHINERY CO., LTD., LONDON, E.C.2

Manufacturers of all types of plant for the coating of aggregates and the production of surfacing material, specialists in plant for working at high, medium or low temperatures for the manufacture of asphalt, all types of bituminous surfacing material, tarmacadam and cold mix. The wide range of standard plant can usually be modified in small details to meet individual requirements, or where necessary, special plant can be built.

Illustrated in Plate IV, No. 7 is the HIGHWAYS COMBINED SELF-CONTAINED OIL FIRED DRYER AND MIXER, which is built in capacities of 5 and 8 cwt. per batch and arranged for either high or low temperature working. Drying and mixing is carried out in the same drum, and equipment is provided to eliminate any danger from fire.

The TRAILER CONCRETE MIXER obviates the necessity for barrowing because the machine can be kept right up to the work. The machine has been designed to secure the maximum manœuvrability on the job, and to allow for fast towing between one contract and another without the necessity of loading onto road vehicles.

The OVER-DRIVEN ROLLER PAN MIXER illustrated in Plate IV, No. 12, has overhead drive, providing easy access to crown wheel and bevel pinion. The gearing is well away from the mix and is protected by a quickly detachable steel guard. A detachable section of the pan side gives access to the rollers and rotating mechanism for the adjustment of the mixer blades, withdrawal of roller bushes and roller shaft, etc. Quickly adjustable roller pressure, up to 1 ton on the two rollers is made by a hand wheel. The engine is totally enclosed, and the roller chain drive completely isolated from dust and grit.

MIRACLE MILLS, LTD., LONDON, S.W.10

"MIRACLE" hand-operated machines in three sizes for bending metal when cold. Indispensable for repair and production.

GEO. MONRO, LTD., WALTHAM CROSS

The "MULTIDOZER" multi-purpose bulldozing and traction machine for back filling trenches, ground levelling, soil spreading, spreading road materials and hauling trailers, etc. A strongly reinforced blade, 72 in. wide by 21 in. high, electrically welded, with interchangeable cutting edge, runs in amply dimensioned bearings. The precision screw jack is totally enclosed, running in ball-thrust and phosphor-bronze bearings. The blade weight is counter-balanced and the operator merely has to set blade, the screw jack holding it in the set position. "ROTAPED" tracks, fitted with heavy duty type track joints on Fordson major tractor give traction of approximately 5,000 lb. (Plate IV, No. 11.)

THE MOORLANDS ENGINEERING CO., LTD., LEEK

Power or hand driven diaphragm pumping machinery, electric, petrol or belt operated.

MORRIS COMMERCIAL CARS, LTD., BIRMINGHAM, 8

A wide range of vans, lorries and tippers from the 15–20-cwt. van to the 5-ton lorry or tipper, for transporting all types of road materials such as sand, gravel and cement, etc.

THOS. MOSCROP & CO., LTD., BOLTON

"LION" Brand oils and greases for lubrication of all types of road plant and vehicles.

MOTOR RAIL, LTD., BEDFORD

"MOTOR-RAIL", diesel-engined dumper, fitted with 20-28 b.h.p. engine, has 6 forward and 2 reverse speeds. It is universally used by civil engineering contractors, etc. for transport where loading or discharge stations are mobile. It has a "struck" measure capacity of 2.8 cu. yds.

MULTIWHEELERS (COMMERCIAL VEHICLES), LTD.

Trailers and semi-trailers for an extensive range of duties in general haulage. The "MULTIWHEELER" provides the answer to most of the present-day transport problems. The range of standardized components is sufficient to cover a very wide variety of types. New trailers to meet specified requirements save money in capital outlay and running expenses.

THE NATIONAL GAS & OIL ENGINE CO., LTD., ASHTON-UNDER-LYNE

4-stroke diesel engines, horizontal types, 10 to 200 b.h.p., vertical types 3½ to 1,840 b.h.p., suitable for driving generators, pumps, compressors, line shafting, etc., and for motive power in locomotives, road rollers, excavators, etc. They are dual-fuel engines which will run on either oil or gas or a combination of the two fuels.

R. H. NEAL & CO., LTD., LONDON, W.5

Today, more than ever before, the attention of hard-pressed road builders is being focused on the employment of labour-saving equipment and particularly on light cranes for speeding highway constructional work. For loading materials and equipment in depots, yards or railway sidings and on the site as the work progresses, for deep trenching and the placing of sewer pipes and mains, for the erection of pre-cast lamp standards, and sewer vent pipes, for culvert construction, bridging, cuttings and embankments—all these phases of work provide many opportunities for the economic employment of light mobile and portable cranes of the one-man-operated, full circle slewing type.

Appropriate models for the various classes of lifting, loading and placing encountered in highway construction, can be found in Neal's new range of mobile and portable cranes, whose lifting capacities range from 8-cwt. up to 4-tons. All these machines have been built to provide useful working radii—with full mobility in the self-propelled types with the provision of heavy duty pneumatic tyres for free movement over unprepared ground surfaces. Each model is powered by a single economical power unit of petrol or diesel type. Plate IV, No. 10 illustrates NEAL'S TYPE "NM", 2-ton capacity mobile crane with 25 ft. lattice jib.

The WINGET-NEAL 7N1 CONCRETE MIXER (Plate V, No. 10), is a new version of the well-known Neal's "RAPID" mixer, the totally enclosed reversing-drum machine, which had built up such a good reputation for high quality and performance with minimum maintenance before the war.

It is now the joint product of Messrs. Winget Ltd. of Rochester, and Messrs. R. H. Neal & Co., Ltd., of Ealing and Grantham.

This model has a capacity of 7 cu. ft. mixed batch, and takes 10 cu. ft. of dry materials. The special design ensures a high output, obtained by efficient rapid mixing and power discharge. The scientifically-shaped helical mixing blades not only shorten the mixing time, but when the rotation of the drum is instantaneously reversed they eject the mix by force in a steady flow of perfectly mixed concrete without separation.

R. H. NEAL & CO., LTD.—(*contd.*)

All the working parts of the machine are encased inside the housing of the mixer, and the gearing and clutches are totally enclosed and running in oil in a single unit oil-tight gearbox, instead of in an atmosphere laden with cement and sand as is usual with the ordinary type of mixer. The mixing drum is gear-driven, fitted with carbon steel mixing and discharging blades, and rotates on machined roller tracks, supported on large diameter ball-bearing fitted rollers. The loading hopper is of the runway type, and operated by a clutch and brake working in oil in the gear-box mentioned above, and controlled by a lever at the end of the machine. The power is supplied either by a twin-cylinder air-cooled petrol engine, or a single-cylinder air-cooled diesel engine. The water supply is of the syphon automatic self-measuring tank type. The mixer is mounted on four pressed steel road wheels with extra heavy treads, and is fitted with détachable tow-bar.

The positive protection of moving parts ensures long life and freedom from breakdown, and the high standard of design and workmanship gives a machine of special interest to the discriminating user who demands the best obtainable.

All the improvements developed from the experience gained during the war years have been embodied in the new ranges to provide the best possible equipment for saving time and labour in urging forward all national and provincial highway undertakings.

NORDBERG MANUFACTURING CO., LONDON, W.1

Large primary jaw and gyratory crushers for the reduction of rock, ore, etc. The gyratories are available in sizes from 72 to 20 in. feed opening and the jaw crushers from 60 × 84 in. to 30 × 42 in. Standard and short head types of SYMONS PATENT CONE CRUSHERS for the secondary reduction of concrete aggregates, chippings, grit, and ball mill feed in metalliferous mines, are available in standard sizes of 7 ft. to 20 in., and short head cone crushers from 7 ft. to 2 ft.

There are various sizes and types of screens, SYMONS GRIZZLES for primary scalping, SYMONS ROD DECK type for secondary scalping, SYMONS "F" type for finished sizing and SYMONS HYDROSIZER for the screening of slurries, etc.

All these machines are in use wherever hard minerals and rocks have to be reduced and separated into sizes.

NORTH BRITISH RUBBER CO., LTD., EDINBURGH, 3

"NORTH BRITISH" DELIVERY, SUCTION AND PNEUMATIC DRILL HOSE, available in various thicknesses and in a range of internal diameter sizes from $\frac{3}{16}$ to 6 in. In the suction hose various types are available, such as exposed internal wire, semi-embedded and embedded wire—smooth bore. "NORTH BRITISH" hose is built to give maximum strength and durability and is suitable for highway engineering purposes.

NORTHERN & MIDLAND COUNTIES ROAD SURFACING CO., LTD., YORK

Agents for SOLO-PICK, a handy portable tool, manually operated, which consists of a rubber handle, striking hammer and outer holder with diamond or chisel end. It is useful for all kinds of demolition work, chasing, channelling, tunnelling, road-making and breaking up concrete, etc., especially useful for jobs where a compressor would be too expensive or could not be brought to work efficiently in inaccessible places.

JACK OLDING & CO., LTD., HATFIELD

Distributors of all BARBER-GREENE, CATERPILLAR TRACTOR CO., and R. G. LE TOURNEAU, INC., EQUIPMENT.

The self-propelled BARBER-GREENE FINISHER unit receives and lays all types of bituminous material and provides a level surface of uniform compacted density with straight edges and correct cross-section crown. Thicknesses of surface can be varied from $\frac{1}{2}$ to 6 in., in widths of 8 ft, 10 ft. and 12 ft., at speeds varying from 8 to 44 ft., per minute. On rough, uneven areas the Barber-Greene finisher provides a perfect, smooth-riding surface and makes an outstanding job of compacting and bonding joints between mats (see Fig. 10, page 405).

BARBER-GREENE DITCHER is an all-purpose, fully crawler-mounted machine for cutting trenches 18, 21 and 24 in. wide from surface level to 8 ft. 3 in. deep. The vertical boom permits the ditcher to work right up to any obstruction encountered, leaving the very minimum of spoil to be excavated by hand. High-speed operation is provided by the special milling-action digging, the driving mechanism of which is protected from damage by the Barber-Greene automatic overload release. Other features include self-cleaning buckets, adjustable spoil conveyor and simplified controls which permit extremely accurate operation, particularly in close work. (Plate IV, No. 3.)

With its spiral feed and swivel spout discharge, the BARBER-GREENE 522 BUCKET LOADER gives a loading rate of up to $1\frac{1}{2}$ cu. yds. per minute, in one continuous flow, and is self-propelled to provide movement in the yard and stockpile crowding. The positive feeding action is fully protected by the BARBER-GREENE automatic overload release which slips when an overload occurs and automatically resets itself. Highly portable—can be towed by ordinary road transport from job to job at 20 miles per hour. (Plate IV, No. 9.)

Continuous mixing with BARBER-GREENE MIXERS means handling a much smaller amount of material at any given moment. Aggregates and bitumen are fed into the charging end of the pug mill in a small continuous stream of the correct proportions. The pug mill needs only to mix cross-sectional increments of the continuous flow, not separate lump masses in large batches.

Continuous mixing requires "Automatic Volumetric Proportioning". The reliability and accuracy of the positive displacement pump fitted to all Barber-Greene Mixers has been proved over many years' service in bituminous construction. The positive apron feeder and calibrated gate on all Barber-Greene mixers has demonstrated its constant measuring control on single and divided multiple aggregates.

The BARBER-GREENE DRYER removes aggregate moisture for bituminous construction and heats aggregates to the required temperature. Its high capacity is used to advantage in conjunction with the Barber-Greene continuous flow pug mill mixers. The flame of the dryer is introduced at one end of the drum where fuel oil is burned in a high-pressure burner with air injection and the wet aggregates are fed in at the other end using the counter flow method. Aggregates are fed through the rotating drum, which is set at a suitable angle, and are elevated and spilled by cupped flights. These flights are shaped and spaced to ensure cascading across the entire cross-section of the drum, thus giving intimate contact with the hot gases.

In August 1931, the first successful Diesel tractor ever built in America was announced by CATERPILLAR TRACTOR Co. The introduction of this machine was preceded by years of research in which neither brains nor money were spared in order to obtain an engine qualified in every respect for dependable, economical operation in heavy-duty service. That its design was right is indicated to-day by records of the first machines built, many of which have seen over 15,000 hours of hard work and some of which have operated over 20,000 and even 25,000 hours.

In addition to this background of Diesel experience "Caterpillar" has also unequalled experience (over 35 years) in the design and construction of track-type tractors. From the very first it has been the pioneer in the design of this type machine.

The tractors range from the D2, with a drawbar horse-power of 25.86 and an area of ground contact (with 12 in. track shoes), of 1,308 sq. in. to the D8, with a drawbar horse-power of 113.14.

The CATERPILLAR W10 wagon has a capacity of 11 cu. yds. and a length of 21 ft. (with CATERPILLAR DW10 tractor, 32 ft. 8 in.).

The CATERPILLAR No. 12 MOTOR GRADER has a tandem drive and single low-pressure tyres. The engine is a 6-cylinder four-cycle, water-cooled. This machine is shown in Fig. 7, page 318.

JACK OLDING & CO., LTD —(*contd*)

CATERPILLAR tractors types D2 and D7 are illustrated in Plate V, Nos 5 and 6

Equipment manufactured by R G LE TOURNEAU, INC, Peoria, Ill, U.S A, includes a modern line of high-speed, off-road, rubber-tyred earthmoving construction and haulage equipment plus a full choice of tools for work with crawling tractors These are the Le Tourneau rigs which have proved themselves on major construction and earthmoving projects all over the world

The TOURNAPULL is a big rubber-tyred prime mover designed for high-speed earthmoving on both long and short hauls Tournapulls are now in use on projects such as roads, reservoirs, airports, railroads, stripping and other earthmoving jobs The Tournapull scraper unit excavates, hauls and spreads its own load Its two-wheel design gives greatest possible tractive power (Plate V, No 1.)

The high-speed TOURNATRAILER is built for carrying excavators, etc, and is used to haul rock, coal, ore and other materials not suitable for scraper loading The W210 model carries 17 heaped yards It has a large opening for fast loading, big tyres for off-road hauling, and positive control rear dump

Manufactured in three sizes, 20, 30, 40 ft boom lengths with lifting capacities up to 50,000 lb, TOURNACRANES load and unload railway wagons, erect structural steel, lift and place heavy machinery, culverts, poles, yards and docks, etc Big tyres for off-road haul permit work in out-of-way places

Ruggedly built to excavate, haul and spread all types of materials, LE TOURNEAU CARRYALL SCRAPERS are built in sizes from 4 to 23 heaped yard capacities Clean positive controlled dump with ejecting tail-gate These Carryall scrapers will work with any make of crawling tractor equipped with double-drum power control unit (Plate V, No 2)

The TILTDOZER is a tool combining the features of an Angledozer and Bulldozer designed for all types of heavy clearing and pioneering work Its strong, narrow blade is light in weight and mounts close to tractor nose The blade can be easily tilted up to 12 in at either end for quick penetration and cutting in on side-hill work

LE TOURNEAU ROOTERS give safe breakage of shale, gravel, concrete and rocky materials, frozen ground without blasting Rugged, strong, built in two sizes, this rooter will work with any crawling tractor fitted with a power control unit

Fast, powerful in all temperature extremes, LE TOURNEAU POWER CONTROL UNITS provide standard cable control for the complete line of Le Tourneau equipment Operating adjustments can be made easily and without the use of special tools

LE TOURNEAU SHEEP'S FOOT ROLLERS with their tapered foot design, give two-way tamping action, insuring both downward and sideward compaction to maximum depth. The feet are self-cleaning and able to walk out of the ground without kicking up dirt

FREDERICK PARKER, LTD., LEICESTER

CONCRETE MIXERS These fall into 3 main classes—the "LITTLE GIANT" hand-fed mixers, the loader-fed tilting drum type "SPEEDIA" mixers, and the mechanically-fed "NON-TILT" series

The "LITTLE GIANT" is made in two sizes, batch capacities of 5/3½ and 7/5 Noteworthy features are the patent adjustable quick-mixing drum, geared tilting mechanism, adjustable roller bearings to the main and drum shafts, transmission by roller chain and machine-cut sprockets, and steel bonnet-type housing for the engine and main drive, giving complete accessibility. Two and four-wheel chassis are offered, and there is a stationary belt-driven Mixer for permanent site work (Plate VI, No 6.)

The "SPEEDIA" tilting drum automatic loader type mixer is made in 3 sizes, 7/5, 10/7 and 14/10 cu ft batch capacity Outstanding mechanical features are the synchronized mechanical feed of water and aggregate, ensuring high quality mix, and a self-measuring water tank, which automatically measures the correct quantity of water and empties itself without manual control

The NON-TILT MIXER is available in 2 sizes, 10/7 and 14/10 cu ft. batch capacity For high-speed trailing, there is a "MOBILE MIXER"—10x7 cu ft size, mounted on two heavy duty pneumatic tyres and with automatic brakes (Plate V, No 8) Rapid and thorough mixing and a high rate of discharge are ensured by the well-designed mixing drum and discharge buckets, and for batch-splitting there is easy control to the discharge chute

STONE CRUSHING MACHINERY —Special attention is drawn to the extreme range of stone crushers and granulators described in the catalogue appropriately entitled "Crushing Evidence" which includes single and double Toggle CRUSHERS, ranging from 12×7 to 30×18 in mouth opening The DOUBLE TOGGLE SUPER BLAKE CRUSHERS can be obtained with the now famous "Hydrol" bearings, incorporating automatic oil lubrication

In addition, there is the "KUBIT" ROTARY HAMMER IMPACT BREAKER for producing excellent cubical roadstone and chippings, being available in sizes from 5 to 60 tons per hour (Plate V, No 7)

Messrs Parkers have made a careful study of mobility in crushing plant, and have quite a lot of designs which will appeal to those requiring portable outfits especially for overseas use, for roadside or site work, etc

ASPHALT AND TARMACADAM PLANT —An entirely new design of plant is now available of 20/25 tons per hour capacity especially built for easy transportation, being made in three sections, the feeding, drying and mixing units, each mounted on pneumatic-tyred chassis, linked into one plant for operation It embodies the oil-fired rotary dryer, horizontal "Oscillex" screen for four separations, also aggregate and bitumen weighing machines, whilst the mixer is the double shaft type paddle mixer The power unit is incorporated in the plant and there is an amazingly simplified pneumatic control of operations Other outstanding features are the ease and simplicity of erection and accessibility Two smaller plants of 5 and 10 tons capacity are also being manufactured

F PERKINS, LTD, PETERBOROUGH

Diesel engines for goods and passenger vehicles and industrial and marine applications This firm operates a "Perpetuity" plan for replacement of engines, it has numerous advantages and is an effective insurance for every Perkins Diesel owner

THE PHOENIX ENGINEERING CO, LTD, CHARD

Road surfacing machinery for all tar, asphalt and bitumen work A wide range of tar and bitumen boilers and sprayers is available Capacities range from the 10 gallon "PHOENIX RAPID" vertical boiler which is ideal for small repairs and patching, to the 1,000 gallon "PHOENIX RAPID" stationary pattern Capacities of spraying machines vary from 160 to 1,000 gallons MASTIC ASPHALT MIXERS give a uniform and continuous mix to any standard specification Each mixer is mounted on a fully-sprung chassis and is shod with pneumatic-tyred wheels The pans which can be cylindrical or "U" shaped are of heavy mild steel plate and a special type of electric steel stirrer is operated through machine-cut worm gear and short belt drive The firebox, which is designed for rapid heating, can be arranged for either solid fuel or oil firing Mixers are lagged to prevent loss of heat due to radiation Standard sizes are 1, 2, 2½, 3 and 4 ton

GEORGE PIKE, LTD, BIRMINGHAM, 6

Diaphragm pumps with renewable bearings and brushes, fitted manifold and valves combined, and worked in conjunction with Lister engines by means of Renold chain drives Standard equipment includes 20 feet of internally and externally armoured suction hose complete with foot valve and strainer Capacities range from 4,500 gallons per hour to 16,000 gallons per hour.

"STAR" INDENT ROLLERS for concrete, granolithic, asphalt, etc, for indenting steep drives and paths, and helping to prevent the surface cracking Grooving rollers are available

GEORGE PIKE, LTD —(*contd*)

or street concrete and asphalt work in four sizes 14 × 5 in, 16 × 5 in, 18 × 5 in, 20 × 5 in with an extensible handle Zigzag or diamond pattern as desired

Recent developments marketed by Geo Pike, Ltd, include "GEOPI" adjustable extending Trench Braces, in four size ranging from 15/22 in to 40/66 in, and an Asphalt Roller, water ballast, 4½ cwts empty and 7½ cwts full (See also "Progress in Traffic Control Devices", page 103)

J. & F POOL, LTD, HAYLE

Specialists in screening and mechanical handling plant used by highway engineers, including "SUPERFLEX" FOUR STREAMS and "PERFEX" ROTARY SCREENS for stone, gravel and sand "SUPERFLEX" FOUR STREAMS ROTARY WASHERS and SINGLE BARREL WASHERS, both contra-flow and uni-flow type Fixed and portable conveyors, and complete stone, sand and gravel washing, crushing, screening and storage plants

HENRY POOLEY & SON, LTD, BIRMINGHAM, 5

Various capacities and sizes of weighbridges to suit all types of road vehicles handled

F W. POTTER & SOAR, LTD, LONDON, E C 2

"RAOS" steel woven wire screening in all meshes and gauges for sieving and screening of road aggregates

J A PRESTWICH & CO, LTD, LONDON, N 17

J A P Industrial Air-cooled Engines for all types of road equipment, incorporating the 4-cycle design, high tension impulse magneto developing a hot spark at low engine speed, and the J A P patent system of lubrication

PRIESTMAN BROS, LTD, HULL & LONDON

The Priestman range of excavators includes the "CUB", "WOLF", "PANTHER" and "LION" models with standard scoop capacities of ¼, ⅜, ½ and ¾ cu yd respectively

The three smaller machines are most widely used for road construction and maintenance, and can of course be fitted with attachments suitable for carrying out various types of work The attachments mainly used for work on roads are the face shovel for general bulk earth moving and loading of materials, digging cuttings, etc, the skimmer for levelling, and the trencher for cutting drains, sewer trenches, etc A variety of types can be supplied to suit trenches of depths down to 14 ft. and widths from 12 in. upwards

With the exception of the "LION" each type of excavator uses one Universal jib for operating any of the attachments mentioned above, and in the case of the "CUB" and "WOLF" one scoop is used for both trenching and skimmer work If necessary lifting crane details can be fitted to the Universal jib.

Plate VI, No 7, shows the "CUB" with skimmer attachment, and Plate VI, No 11 the "WOLF" with trench attachment

FREDK. A PULLEN & CO, LONDON, S E.11

WOBBLY WHEEL ROLLERS with nine smooth-tread pneumatic-tyred wheels on oscillating axles The nett weight of roller is 2½ tons, and total weight when filled with sand or ballast is 10 tons The loading of the rollers can be adjusted up to a maximum of 12 tons gross to obtain the best results on any type of soil or mixture and ensures maximum and uniform density compaction over the area to be rolled in an exceedingly short time (See Fig 11, page 322, article on "Road-making Plant and Machinery".)

RANSOMES & RAPIER, LTD, IPSWICH

The RAPIER range of excavators includes all types and sizes of shovels, draglines, trenchers, skimmers and grabs, from ⅜ cu. yd to giant stripping shovels and walking draglines with bucket capacities up to 20 cu. yds.

The smaller size machines are used extensively for trenching, levelling, digging from the bank and cranage as well as for excavating sand, gravel, clay, etc A notable feature of the smaller size machines is the easy interchangeability of the front end equipments which can be changed over on site Thus with one machine, front end equipments can be supplied for shovel, trencher, skimmer, dragline, grab, piledriver or crane

The RAPIER 410 EXCAVATOR is fitted with a four-purpose equipment which includes all parts for use as shovel, trencher skimmer and crane by a simple re-arrangement of the parts, no extra parts being required Re-arrangement of the front end equipment from one form to another can be carried out in the field in about half an hour This represents a great saving in initial cost, transport charges and change-over time and makes the machine particularly suited for mixed contracting work (Plate VI, No 4)

One of the most important developments in the design of these smaller excavators is the fluid coupling transmission which was first introduced by Ransomes & Rapier Limited By its adoption bigger output is obtained with less wear and tear and simpler control

The RAPIER concreting machinery includes mixers and placers, batching plants and spreading and vibrating machinery

A wide range of mixing requirements is covered by tilting drum machines (Plate VI, No 8), which are made in four sizes from 3½ to 7 cu ft mix capacity and non-tilting machines in six standard sizes from 5 to 28 cu ft mixed batch capacity The machines are normally mounted on steel disc road wheels but pneumatic-tyred wheels can be supplied Standard machines have either petrol, diesel or electric drive All machines excepting the smallest size tilting drum are fitted with power-hoisted loading skips and automatic measuring water tanks are fitted

Several types and sizes of concrete paver mixers with swinging booms and travelling buckets for placing the concrete are available A particularly interesting machine is the RAPIER 14R PAVER which is a crawler mounted machine with 21/14 cu ft capacity mixing drum and 20 ft long boom The machine is driven by 35 h p Diesel engine and is specially fitted for road building (Plate V, No 12)

RAPIER TRUCK MIXERS (Plate V, No 9) are made in two sizes, 1½ cu yds and 2½ cu yds mixed batch capacity

RAPIER BATCHING PLANTS are equipped for full weight control of aggregate, cement and water and have a simple correction device which compensates for the moisture content of the aggregate By this system it is possible to supply concrete to strength specification owing to the scientific accuracy with which batching and mixing are controlled

The mechanical spreading of concrete in road construction and its compaction by high frequency vibration for uniformity of laying and maximum strength are now established facts The RAPIER SPREADER AND VIBRATED CONCRETE FINISHER is a power-traversed machine with spreader screw, vibrating strike-off plate and vibrating beam, in which many patented features are incorporated, enabling the machine to spread and compact a very dry mix leaving a dense concrete free from cracks (Plate V, No. 3)

A hand-traversed road vibrating machine consisting of a strike-off plate and vibrating beam is also made

Both the RAPIER SPREADER AND VIBRATOR and the RAPIER HAND TRAVERSED ROAD VIBRATOR are supplied in various widths but the standard machines are adjustable for laying strips from 8 to 12 ft. wide

A smaller vibrator known as the PAN VIBRATOR is made for vibrating small areas, such as road or floor repairs or narrow extension widths. By using this machine a better bond is obtained between the old and new concrete in repair and patching work

The RAPIER SPREADER for asphalt and hard core reduces laying costs and gives more even spread and smoother surface. The machine is adjustable in widths from 8 to 12 ft. and will spread thicknesses from 1 to 10 in. The spreader is towed behind the lorry which delivers the material. The lorry discharges the material into the spreader hopper and pulls the spreader forward in one continuous motion.

PLATE V

1 AND 2, R. G. LE TOURNEAU "TOURNAPULL" AND "CARRYALL" SCRAPER. 3, 9 AND 12, RANSOMES & RAPIER SPREADER AND CONCRETE FINISHER, TRUCK MIXER AND No. 14R PAVER. 4 AND 11, RUSTON-BUCYRUS DRAGSHOVEL AND SKIMMER. 5 AND 6, "CATERPILLAR" D2 AND D7 TRACTORS. 7 AND 8, FREDK. PARKER "KUBIT" ROTARY HAMMER BREAKER AND NON-TILT PORTABLE MIXER. 10, R. H. NEAL "WINGET-NEAL" CONCRETE MIXER.

RIP BITS, LTD., SHEFFIELD, 2

Detachable rock-drilling bits, both ordinary steel and Tungsten carbide tipped, for drilling any type of rock or concrete. Bits and rods available in all standard types and sizes in regular use by the contracting industry This equipment dispenses with the necessity for installing blacksmithing and heat treatment equipment, which requires skilled labour and heavy capital expenditure Detachable bits are especially useful, as they are easily portable and can replace blunted bits instantly Bit grinders supplied or blunt bits re-ground by manufacturers

ROADLESS TRACTION, LTD., HOUNSLOW

Makers of "ROADLESS" and "OROLO" tracklaying equipment for driven and undriven vehicles These comprise driven track-laying equipment of the rubber-jointed and locked girder varieties for all types of tractors, cranes and a variety of special self-moving vehicles Undriven "OROLO" track units, with weight-carrying capacities, ranging from 2 cwt to 50 tons, are used mainly for trailers and portable plant.

This track-laying equipment enables all kinds of vehicles to operate efficiently over soft and rough ground surfaces

GEO. ROBSON & CO (CONVEYORS), LTD., SHEFFIELD, 3

Endless rubber belt portable conveyors, inclined and mounted on road wheels in all types and sizes, with fixed or adjustable delivery heights Very adaptable for a variety of purposes, such as forming stock piles and loading vehicles rapidly These conveyors can be fitted with either petrol or electric drives

Other products include screening plant of all types and tramway track grinders mounted on wheels with swivelling head and moving carriage

RUSTON-BUCYRUS, LTD., LINCOLN

Manufacturers of excavating equipment used by many county and municipal authorities for various new projects and on general maintenance work, in conjunction with the usual type of universal machines, to which varying front-end equipment is fitted These base machines are generally mounted on "caterpillars" for mobility, have diesel engine-power units, and are made in sizes ⅜, ½, ⅝, and ⅞ cu yd bucket capacity

A typical example of the adaptability of these machines is their recent use for demolishing air-raid shelters In this case, an excavator with a dragline boom operates a drop weight for demolishing the brick-type shelters, the resultant debris being loaded into lorries by a positive crowd shovel

Front-end equipment includes POSITIVE CROWD SHOVELS for all classes of work above ground level, and DRAGLINES for excavating below ground level and even under water Where the excavation is not too deep or where the material is too heavy to be dug effectively with a dragline, a DRAGSHOVEL is recommended (Plate V, No 4) The dragshovel dipper is held more rigidly to its cut and has the advantages of a shovel but lacks the effective digging range of the dragline

The SKIMMER shown on Plate V, No. 11, skims or takes shallow cuts parallel to the surface, and is especially useful to municipal authorities on road schemes The prising action of the bucket is effective for breaking up old roads and the machine can also load the material

When handling loose material such as sand, gravel, etc., and when transferring them into wagons, or from wagons to stock piles, the GRABBING CRANE or CLAMSHELL is used. The addition of a hook and swivel to the hoisting rope of the GRABBING CRANE is all that is necessary for general crane work, the same boom as for dragline or grabbing crane being used. This addition is extremely useful for miscellaneous lifting work on site

Universal type excavators can also very easily be converted into drop hammer type PILE DRIVERS, with the addition of suitable leaders and braces Similarly, by fitting a large drop weight, these excavators can be employed as TAMPERS for ground consolidation

The largest machines in the Universal range weigh up to 16 tons, but larger shovels and draglines are available with buckets up to 5 cu yds capacity and dragline booms up to 150 ft in length. Machines up to 3½ cu yds capacity are on caterpillar mountings while the larger draglines have "walking" type traction

RUSTON-BUCYRUS BULLDOZERS and BULLGRADERS set a new high performance standard in dirt moving They are especially designed and built for International Tractractors so that the tractor and bulldozer become one properly balanced unit and the greatest use is made of the power, speeds and weight of the tractor They are available in varying blade lengths and heights, and are extensively employed for short haul excavation or for spreading material The ability to side cast its dug load in forward travel is provided for by the BULLGRADER which is an adaptation of the bulldozer It also gives a lower forward point for concentrated digging, such as for shallow pipe channels, etc (See Figs 8 and 9, page 318, article on "Road-making Plant and Machinery")

SCRAPERS are generally hauled by high-powered Tractractors and dig their own load during forward travel of the unit They are provided with a cutting blade which may be raised or lowered in order to maintain a digging depth down to about 10 in. This is pulled through the earth, and the dirt travels up the blade face into a carrying bowl When this is filled, an apron is allowed to close, thus retaining the dirt for subsequent dumping. This operation is controllable, so that the dirt is dumped in front of the blade Forward travel o the tractor allows all the dumped dirt to roll under the blade into the area between the blade and the ground surface

Shallow cutting and thin spreading is a speciality of this type of equipment, and the normal economic length of haul is 600 ft round trip, the maximum being 1,000 to 1,200 ft one way SCRAPERS in the standard range are available in sizes up to 20 cu yds

RUTHERFORD OIL BURNERS, LTD., LONDON, N 1

It has been found that time wastage caused by labour waiting for the tar to be heated to the required consistency can be almost totally eliminated by converting existing tar boilers from solid fuel to oil firing using the RUTHERFORD SELF-GENERATIVE OIL BURNER This oil burner is very easily fitted to all standard types and sizes of tar boiler By starting with a comparatively empty boiler, adjusting the burner to its maximum and gradually building up the quantity of tar, spraying can begin almost immediately The saving of man-hours during bad weather or when labour teams are being constantly switched from one job to another is considerable, and this, coupled with the elimination of coal transportation more than balances the extra cost of fuel A wide range of fuels from diesel to sump waste and chemical residual may be used

The Rutherford burner is extremely simple to operate and easy to maintain Accumulation of carbon or soot is negligible. When for any reason spraying is temporarily stopped the burner may be adjusted to its lowest level and the boiler left unattended, the tar being ready for use when required The risk of fire is entirely eliminated, since the burner can be switched off instantaneously in the event of the tar boiling over

SKYLUX, LTD., LONDON, W.3

"SKYLUX" THRUST BORERS are employed for the installation of underground pipes and cables, without surface disturbance to the permanent way They are hand-operated, pressure being applied by twin pressure screws through a gear-box having two speeds The design is entirely new, and its particular advantage is that it enables thrust boring to be carried out with confidence, because the thrust bore maintains direction and the elevation is made known to the operators of the machine throughout the operation. (Plate VI, No. 3.)

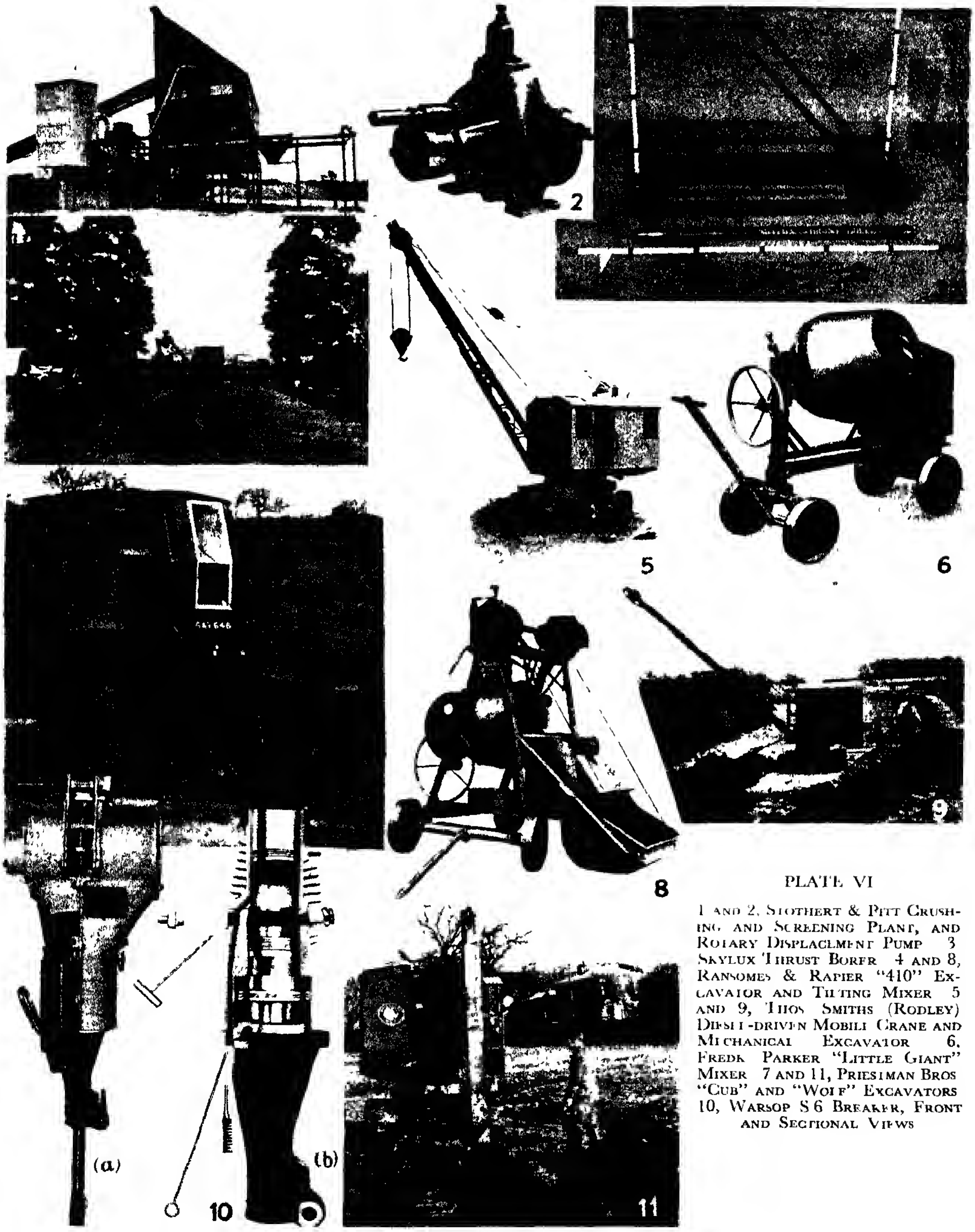


PLATE VI

1 AND 2, STOTHERT & PITT CRUSHING AND SCREENING PLANT, AND ROTARY DISPLACEMENT PUMP 3 SKYLUX THRUST BORER 4 AND 8, RANSOMES & RAPIER "410" EXCAVATOR AND TILTING MIXER 5 AND 9, THOS SMITHS (RODLEY) DIESEL-DRIVEN MOBILE CRANE AND MECHANICAL EXCAVATOR 6, FREDK PARKER "LITTLE GIANT" MIXER 7 AND 11, PRIESTMAN BROS "CUB" AND "WOLF" EXCAVATORS 10, WARSOP S 6 BREAKER, FRONT AND SECTIONAL VIEWS

SMEDLEY BROS., LTD., BELPER

Highway engineers' equipment manufactured includes heavy grinding pan mills and mixers, undergeared and over-geared, revolving and stationary pans with perforated or solid bottoms and either portable or fixed, for the making of mortar, concrete for artificial stone, sand breeze, etc

JOHN SMITH & CO (LONDON, E), LTD

Patent collapsible canvas shelters affording protection for labour and plant in all weathers, easily stored, erected and transported Available in various sizes and weights

Other products include jointers' tents, watchman's huts, portable private lavatories, tarpaulins, tents, flags, etc

THOMAS SMITH & SONS (RODLEY), LTD., LEEDS

This firm has been engaged in the manufacture of lifting machinery for over 120 years and has during this time supplied large numbers of its locomotive steam cranes, etc, to all the largest public works contracts both in this country and abroad

During the past few years, although still meeting the heavy demand for steam cranes, the modern tendency both in design and in practice has been towards the Diesel type, and large orders are in hand for cranes, both the locomotive type on rail wheels and the mobile type on rubber tyres, powered by modern Diesel engines (Plate VI, No 5)

Included in their products is the range of MECHANICAL EXCAVATORS which are normally made in five standard sizes with bucket capacities of ½ to ¾ cu yd capacity The Smith excavator is universal in character, and by the utilizing of different booms and buckets the same base machine can be quickly and easily converted to navvy shovel, skimmer scoop, back-acting trencher or dragline (Plate VI, No 9) It can also be utilized as a mobile crane for either straight lifts or with a grab It is mounted on caterpillar tracks, and these in addition to its low ground pressure make it ideally suitable for work on the softest ground The machine is also capable of climbing a gradient of 1 in 4, therefore, its popularity and adaptability can be readily assessed Special machines have been made up to 1½ cu yd capacity for work in limestone quarries

THE STANDARD STEEL CO (1929), LTD

All classes of structural steel work, either riveted or welded for buildings, bridge work and other purposes Large stocks of mild steel sections are available and quick deliveries of mild steel reinforcing rods, bent to shape can be given Products also include hand and steam cranes, locomotives and light railway track

STOTHERT & PITT, LTD., BATH

Crushing and screening plant producing dried aggregate for tarmacadam Mixing plant shown on Plate VI, No 1 incorporates two 27 cu ft paddle mixers each complete with a rotary batch heater with oil burner Three travelling hoppers, each 15 ton capacity are shown under one of the mixers This type of plant is now being extended to increase the tarmacadam output

POSITIVE ROTARY DISPLACEMENT PUMPS suitable for handling tar or bitumen These pumps are available for mounting on road wagons arranged for chain drive from power take-off gear, and some models have been equipped for road tar spraying Plate VI, No 2 shows size 3A pump, with a steam-jacketed body, reversing flow, special reversing gear and two-way relief valve

(Also manufactured is a vibratory concrete compacting machine, a photograph and description of which is given on p 327 in the article on "Road-making Plant and Machinery".)

HENRY SYKES, LTD., LONDON, S.E 1

Pile-driving machinery for foundations, bridge abutments, etc Pumping machinery for all duties likely to be met with by civil engineering contractors, especially suitable for draining water-logged ground and supplying water for concrete mixers

TASKERS OF ANDOVER (1932), LTD., ANDOVER

This firm have a complete range of over 50 different trailer and semi-trailer lorry models covering load capacities from 2/3 up to 25 tons These trailers can be utilized for every kind of transport including contracting and road-making haulage, and special designs can be completed to requirements

TECALEMIT, LTD., BRENTFORD, MIDDLESEX

Lubricating equipment for all types of plant. The Tecalemit high-pressure lubrication system with TECALEMIT PLASTIGUNS represents a modern development in hand-operated lubricating guns These dual action guns are capable of forcing lubricant into the tightest bearings The JUNIOR HAND COMPRESSOR develops a pressure up to 5,000 lb per sq in, thus ensuring lubrication of the stiffest joints Other equipment includes lubricating pumps, mechanical lubricators, air compressors, lubrication batteries, electric high-pressure lubricators, knapsack compressors, etc

The TECALAMIT VOLUME PUMP for the lubrication of crawler type tractor rolls is also ideal as a loader pump

THOMPSON BROS (ENGINEERS), LTD., LONDON, S E 13

THOMPSON modern design light weight grab winches, and portable winches for transporting and erecting telegraph poles Sizes range from ½/7 tons Specially designed for fitting to commercial vehicles and trailers for trsnaporting machinery

TREWHELLA BROS., PTY., LTD., BIRMINGHAM

A portable hand-powered wire rope winch tree-puller, which will pull over large trees without preliminary digging or root cutting Also useful for pulling out ditched lorries or excavators

TRIANCO, LTD., EAST MOLESEY, SURREY

Machinery for the production of concrete paving slabs and kerbs, etc,

HUBERT H P TRIST & CO., BRISTOL

"TOP-DOG" Brake and clutch linings, asbestos jointings of all types, oil-proof jointings and cork sheeting, for use on all commercial and passenger vehicles and road machinery

VAUXHALL MOTORS, LTD., LUTON

The "BEDFORD" range of vans and trucks for all types of road material haulage, are available in sizes from the 5 to 6-cwt light van to the 8-ton BEDFORD-SCAMMELL articulated vehicle

VULCAN MOTORS, LTD., MAIDSTONE

"VULCAN" goods vehicles, long wheel-base, or tipping chassis with petrol or Diesel engines The 9VFA has an articulated tractor chassis and petrol engine All vehicles suitable for hauling road materials

WARSOP PETROL DRILL & TOOLS, LTD.

The "WARSOP" S 6 HEAVY ROAD BREAKER is an entirely self-contained and portable machine which derives its motive power from a two-stroke petrol engine mounted at the head of the machine in an inverted position Beneath the engine cylinder, in the position normally occupied by the cylinder head, is built a further cylinder and free moving piston which constitutes the hammer unit, and by means of which the power of the engine is transmitted directly on to the pick steel. This free-moving piston is controlled solely by explosion gases and consequently no springs are employed to return it to the top of its stroke.

A noteworthy feature of this machine is that it requires no auxiliary power plant, and is therefore independent of trailing hoses, cables or batteries, a feature which is invaluable from the point of view of portability and ease of operation.

WARSOP PETROL DRILL & TOOLS, LTD—(*contd*)

This useful machine can be used for a variety of additional purposes, such as spading, cutting soft materials, consolidation of ground, driving ground rods or light pile driving, by means of extra attachments which can be supplied on demand (Plate VI, No 10 shows front and sectional views of the machine)

ALEXANDER WILSON (ABERDEEN), LTD, ABERDEEN

Makers of cranes and stone working machinery Specialists in air compressors, both fixed and portable, and pneumatic tools

J J JOHNSTON & CO, LTD, LONDON, S W 1

Specialists in the supply, maintenance and operation of all types and sizes of mechanical plant for civil engineering, with facilities for complete overhaul of customers' machines This company are also advisers and valuers to the trade

WINGET, LTD, ROCHESTER, KENT

CONCRETE BATCHING AND MIXING PLANT for road and other constructional works in which concrete is used It is a recognized fact that central batching and mixing plants are essential in order to obtain the accurate proportioning of materials now being specified, and to supply material in sufficient quantities to keep pace with the speed of laying made possible by improved road making and other concrete-handling plants

For some years Winget, Ltd, of Rochester, has specialized in the construction and design of concrete batching and mixing plants, which may be arranged for operation by manual, semi-automatic or fully automatic means

The concrete mixer used in this plant is the WINGET 1 cu yd double-cone type, which is particularly suited to low-water-content mixing The machine is driven by a 12½ h p squirrel-cage motor and its tilting for the discharging and loading of mix is effected by hydraulic means It is situated well above ground level in order that its contents may be discharged downwards and directly into tipping lorries or dumpers for transport to site

The "WINGET-KOEHRING" concentric zone tilting mixer, which has a rated capacity of 84 cu ft is being used in the larger plants A U-shaped base frame permits the tilting to swing below the top of the main frame and reduces the overall height of the machine The drum has an internal diameter of 91 in, an overall length of 100 in, and its opening is 35 in diameter

The drum is driven at 11½ r p m by a 40 h p electric motor through a pinion mounted directly on its shaft

Two pneumatic cylinders, one at each side of the tilt frame, are used for tilting the drum, which has a charging and mixing angle of 15 degrees above horizontal and a discharge angle of 60 degrees below Rubber blocks stop the tilt frame in its extreme positions, and during the mixing and charging operations, the frame is automatically locked (See also Winget-Neal Mixer, page 345)

H G WITHERS & CO., STALHAM

"PECKS" scientifically designed underslung hand trucks fitted with pneumatic tyres and ball-bearing wheels Available in capacities of 5 to 20 cwt

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The following firms have stocks of plant available for hire

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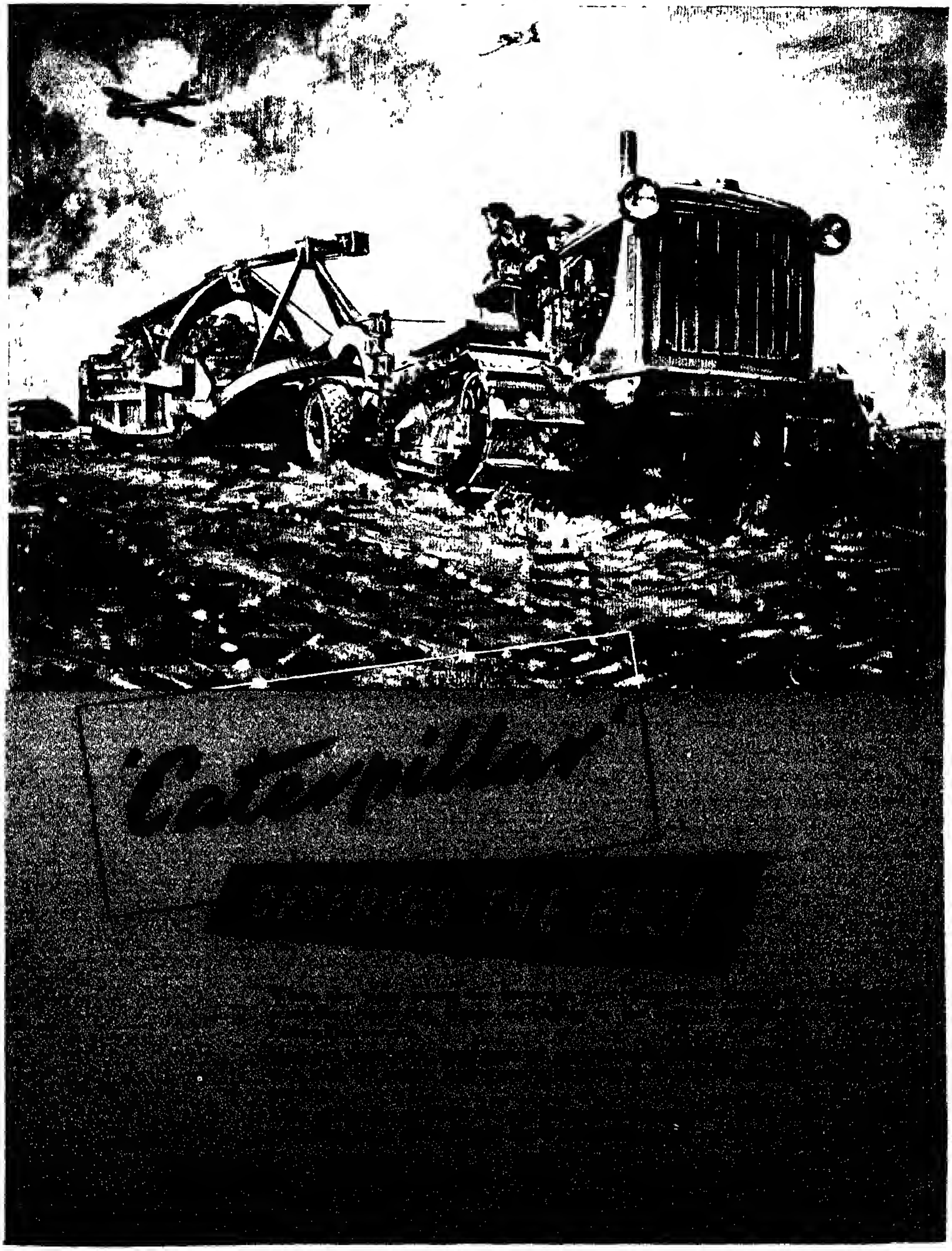
EDDISON STEAM ROLLING CO, LTD, Dorchester
J J JOHNSTON & CO, LTD, LONDON, S W 1
PREMIER PLANT & HIRE CO, LTD, Isleworth
SAXTON & CO (LONDON), LTD, London, N W 5
SOUTH EASTERN ENGINEERING CO, LTD, Maidstone
STRAND HIRING CO, LTD, London, S W 8
WESTERN HIRE CO, LTD, London, W 5

Whilst every care has been taken in compiling this information, the omission of any name must not be held as implying any deficiencies in the products of the company concerned.

For full addresses see Manufacturers' Directory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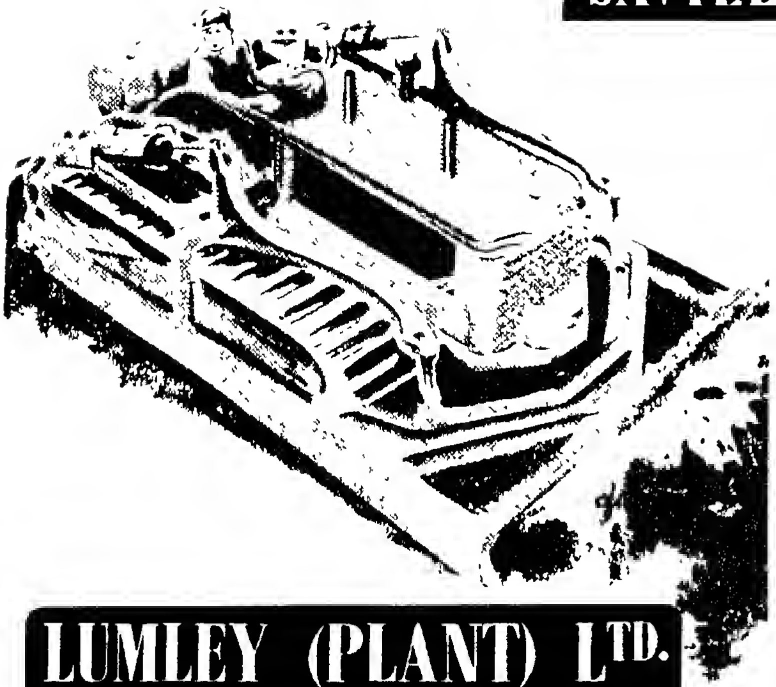

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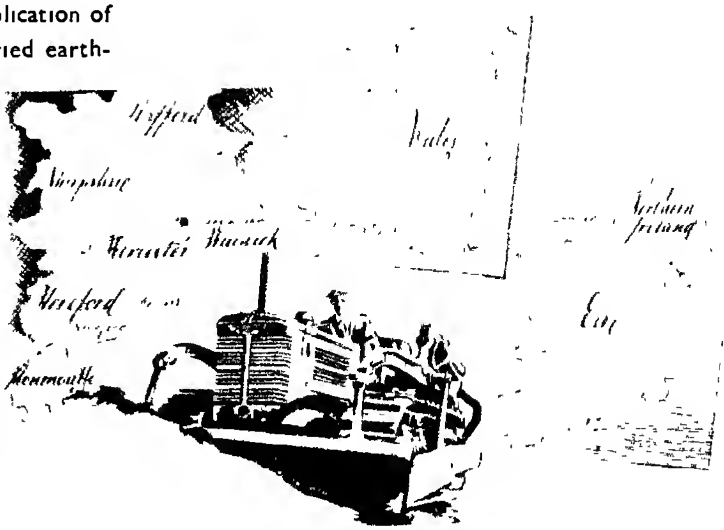

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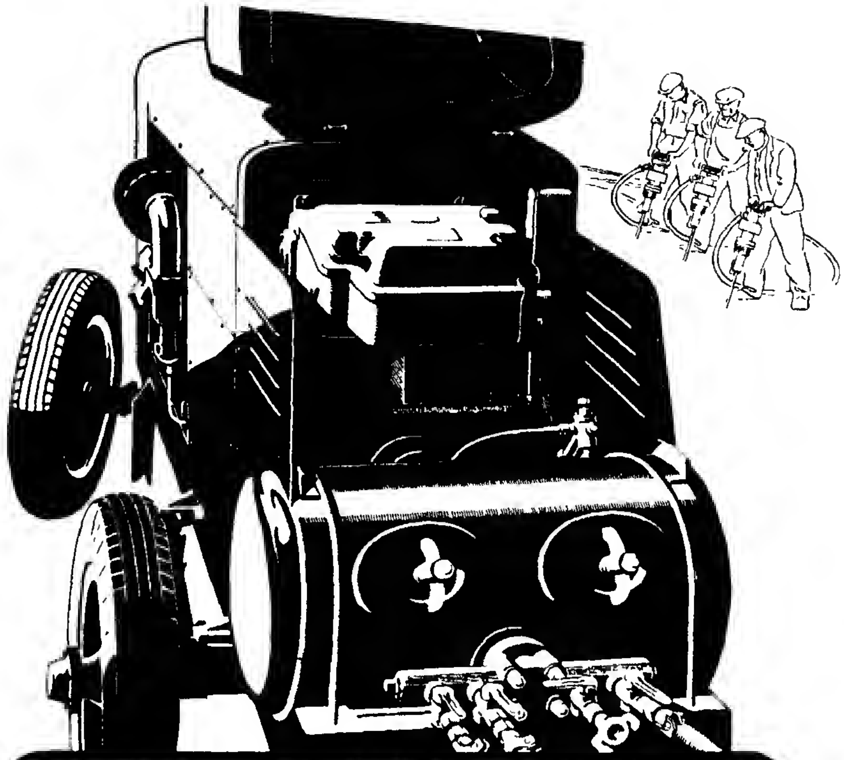

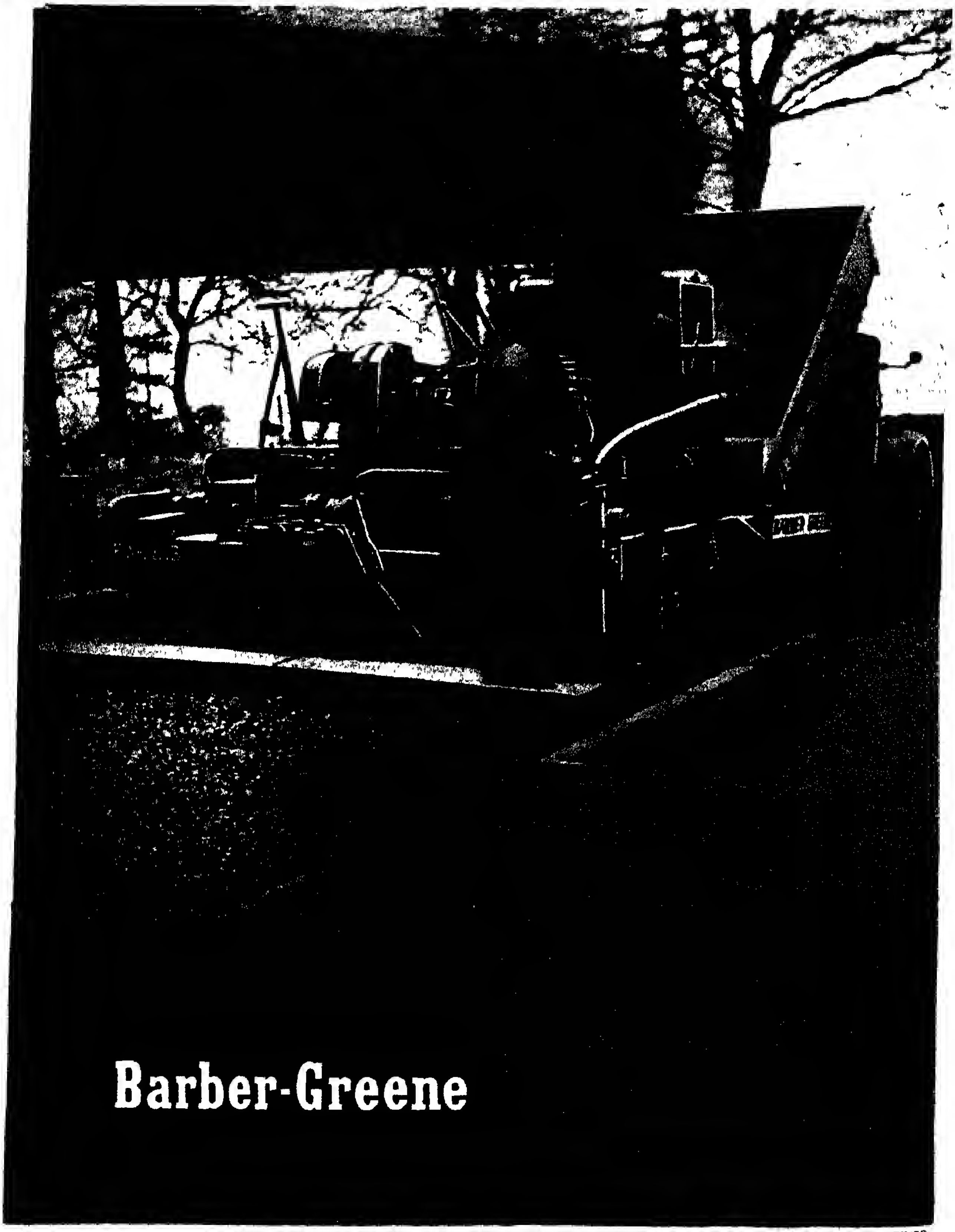
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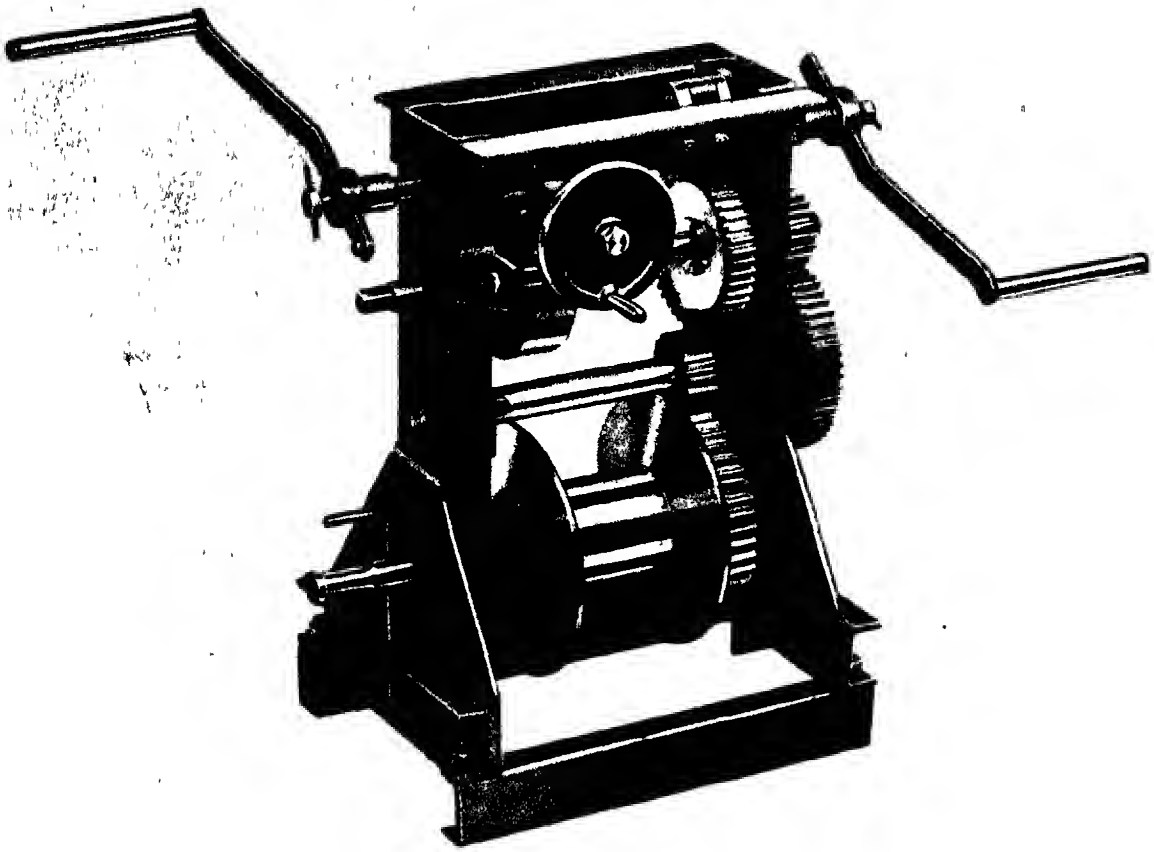

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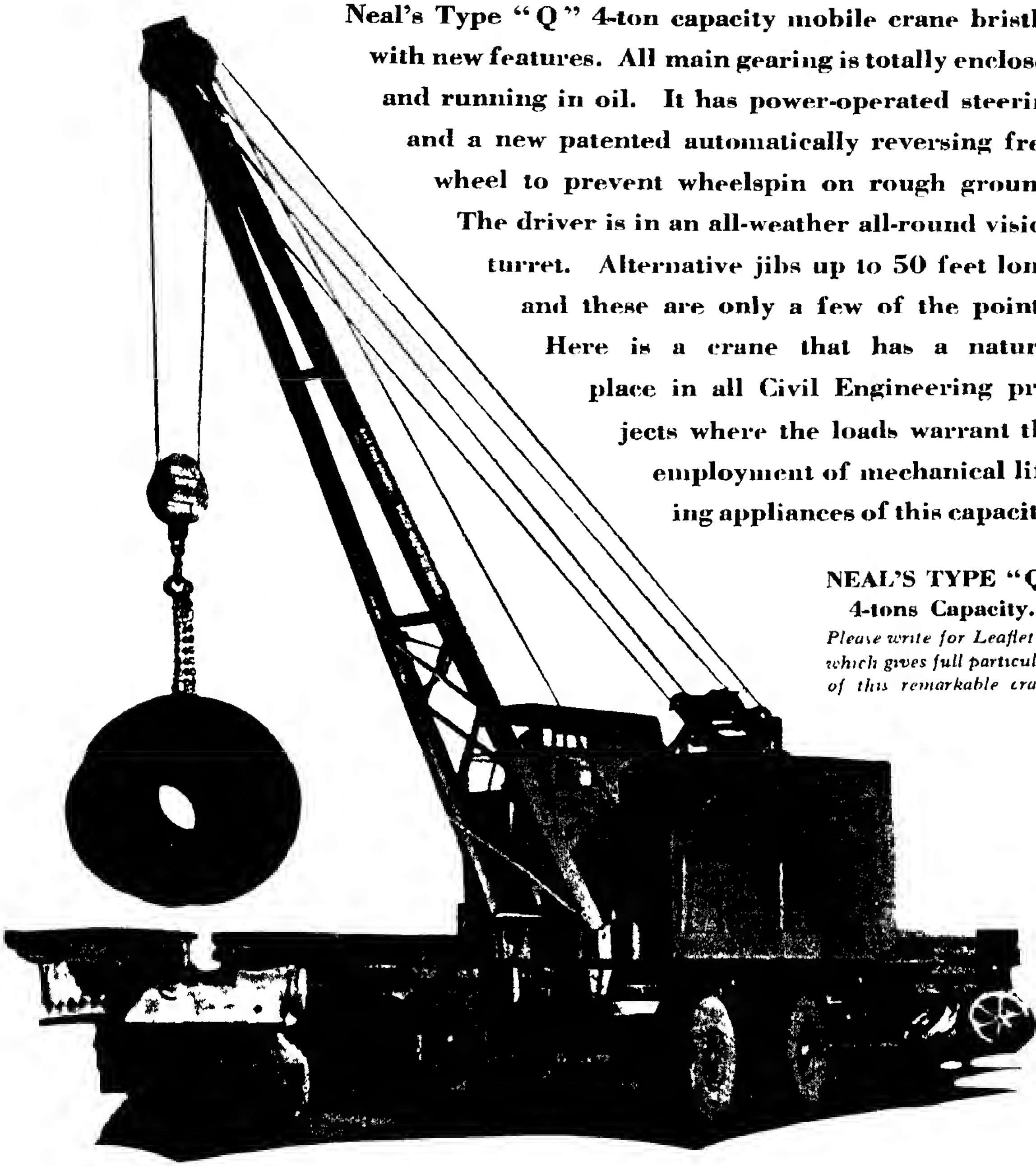

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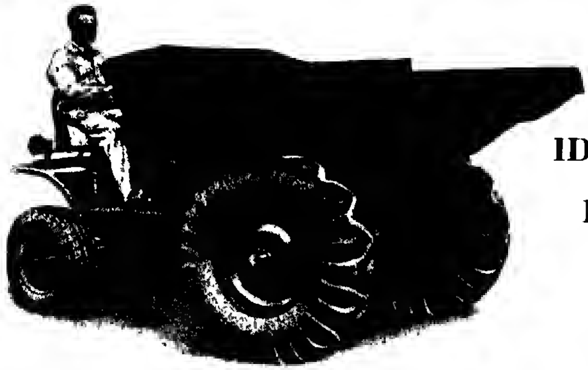

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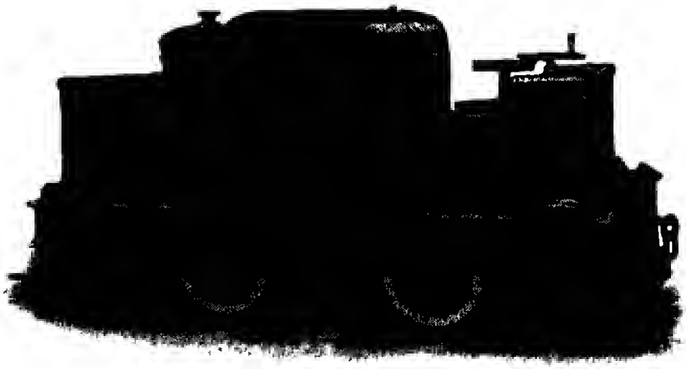

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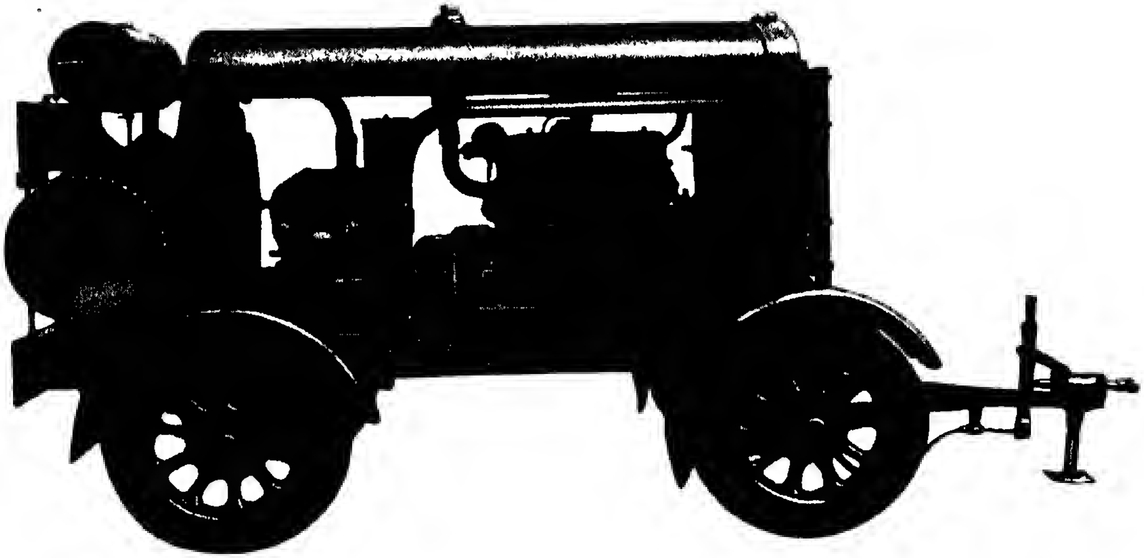

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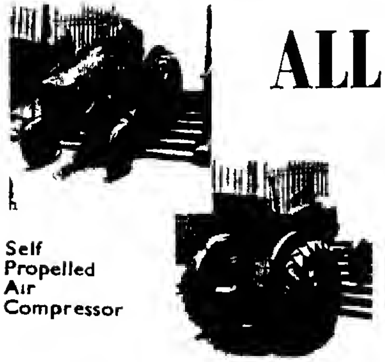

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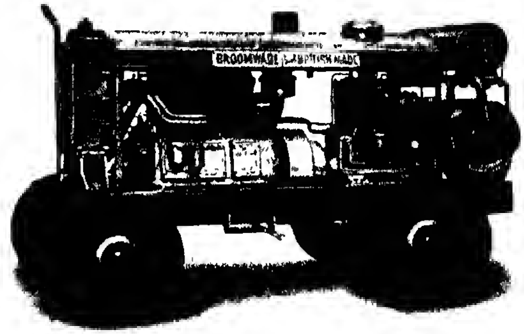

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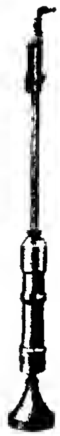

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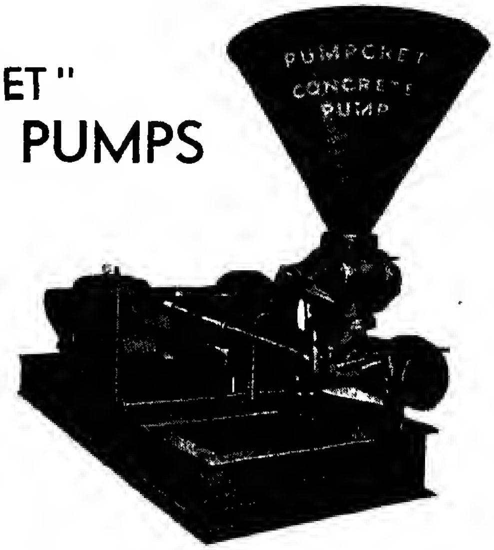

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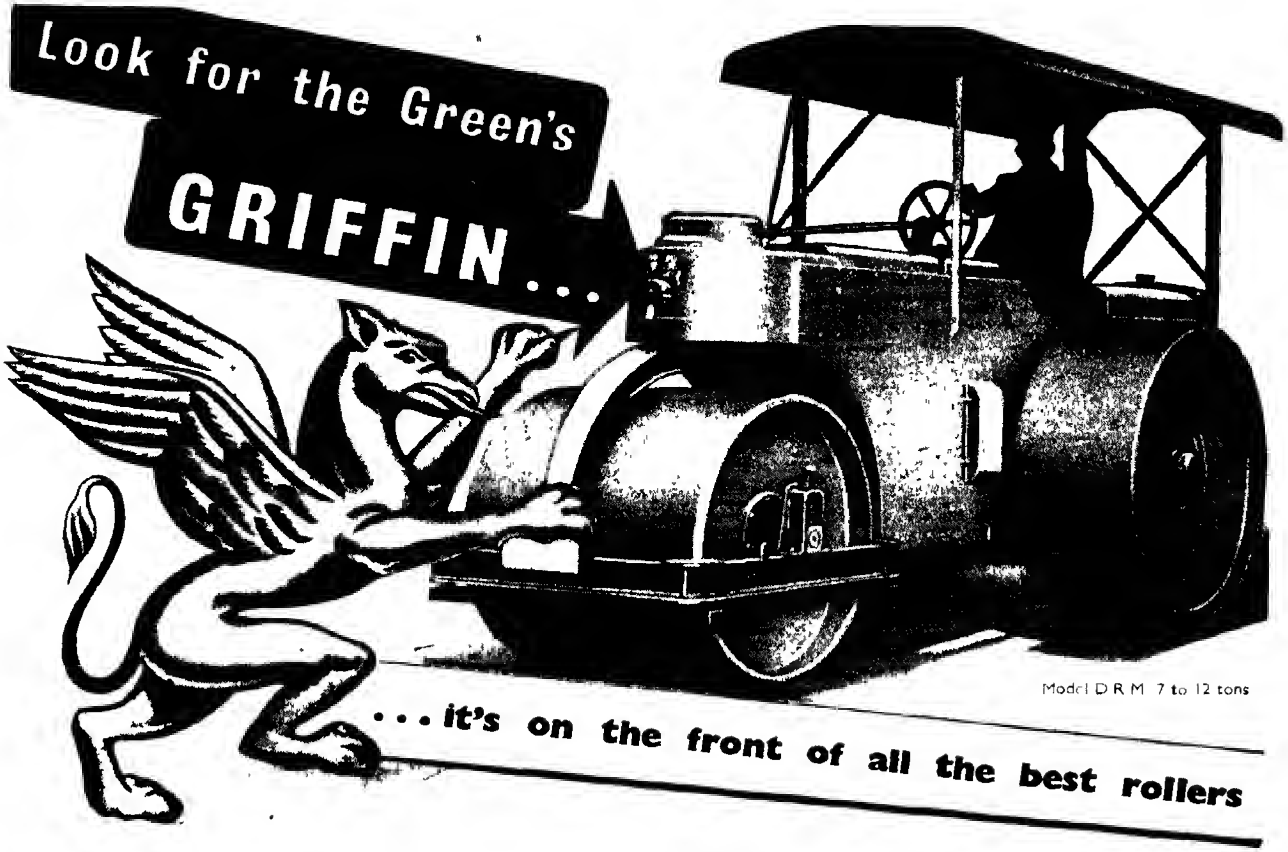

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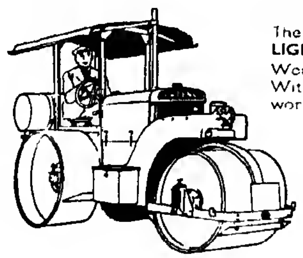

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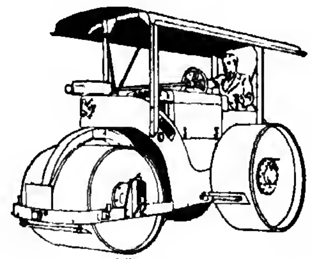

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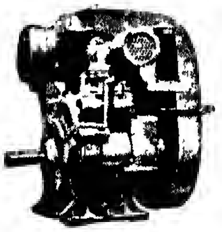

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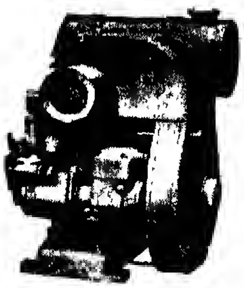

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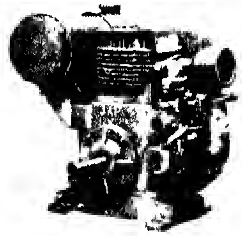

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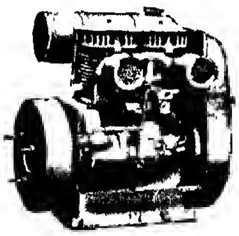

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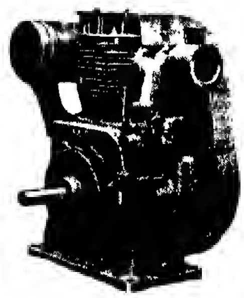

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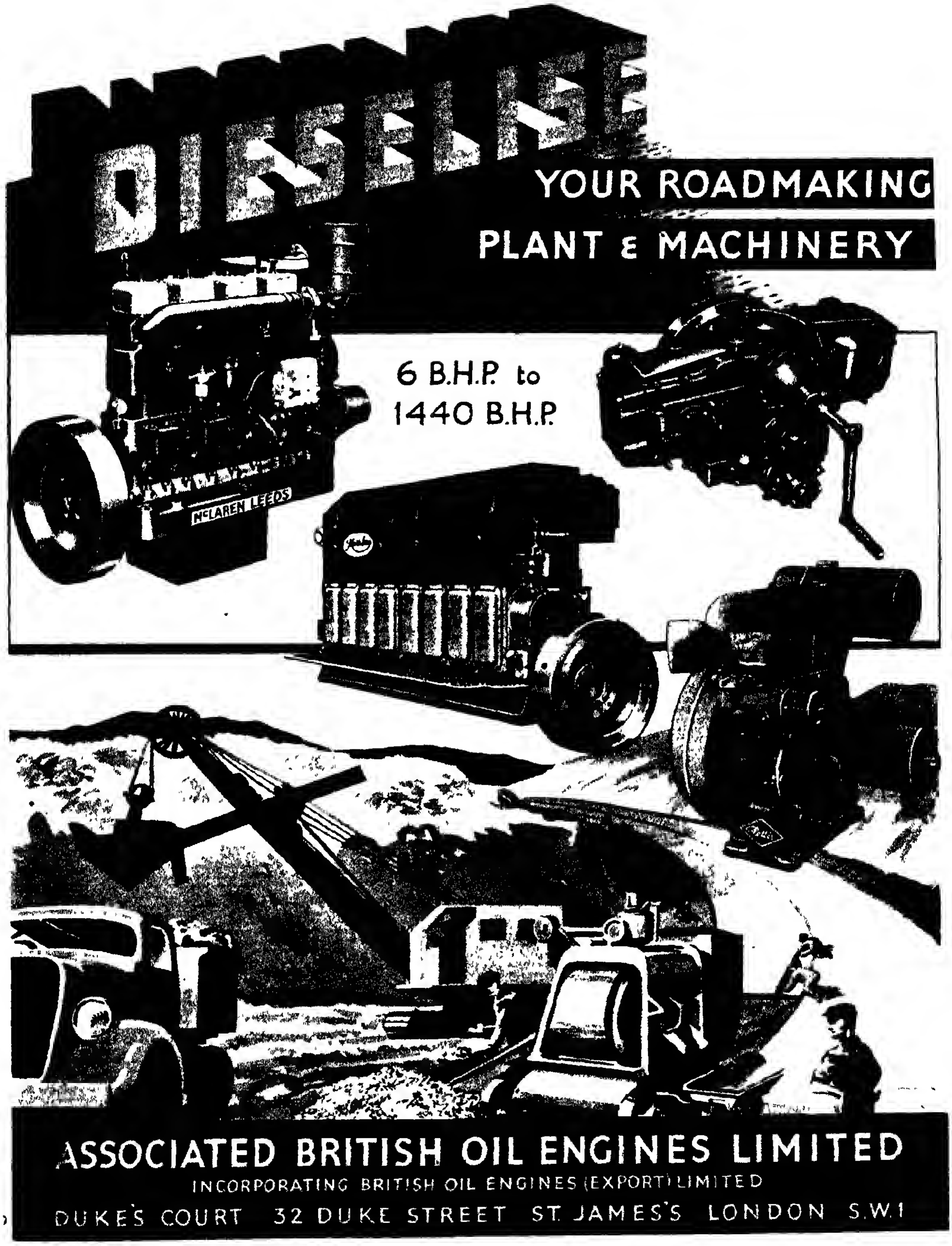
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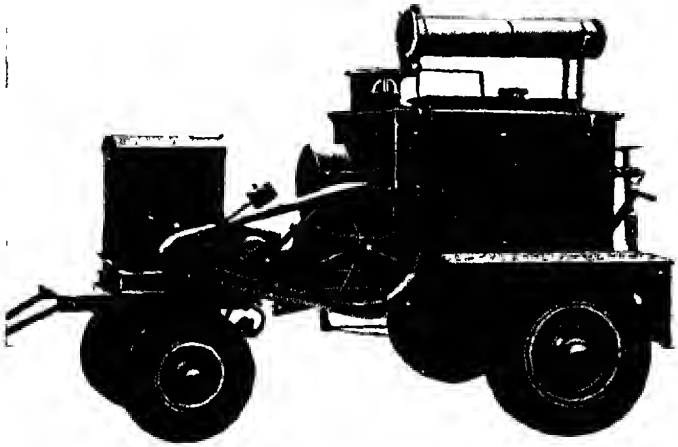

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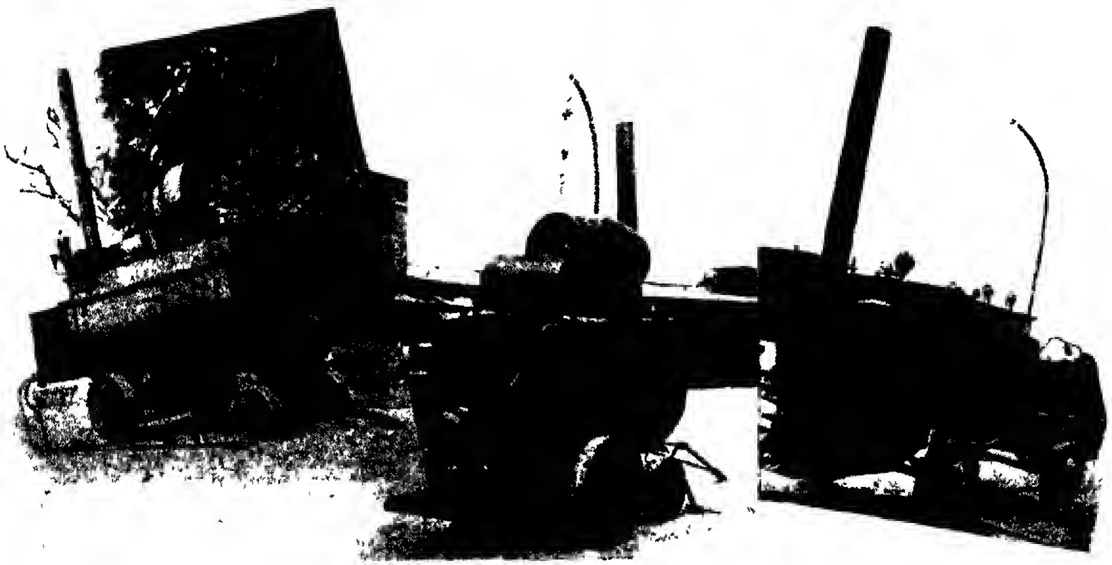

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Section Eight

MAINTENANCE

MAINTENANCE OF HIGHWAYS

By F. S STRONGMAN, A M Inst. M. & Cy E.

In the approach to the design of any type of road surfacing whether constructed as a rigid or flexible pavement it is clear that the expected life must depend entirely on the strength of the foundation This in turn depends upon the subgrade characteristics and bearing capacity of the soil These subjects have been dealt with elsewhere but their importance from the angle of maintenance cannot be overstressed Generally this section will deal with surface maintenance but no amount of surface treatment will save a road in which the foundations are faulty or the subgrade below standard (see Fig 1). If failure of a road surfacing is attributable to either of the above causes it is an economy to start repairs from the lowest point of failure

Again, careless or faulty repair may result in the final condition of the road being worse than the first. A patch in the surface which stands proud of the surrounding area causes the traffic to bounce and consequently a hollow forms beyond the patch; the hump and hollow soon become continuous, when only reconstruction will cure the trouble. Similarly waves caused by initial under-compaction of the surfacing material will spread rapidly.

Other causes of surface failure are poor drainage and meteorological conditions such as frost, snow, heat, etc Most of the troubles from these causes can be avoided by normal routine care and maintenance

Drainage is usually of prime importance in the initial construction but it is of equal importance to maintain the grips, gullies, drains, etc. in a clean and serviceable state

As regards surfacings and surface dressings, the practice of control and selection by rule of thumb methods is passing All engineers now realize the need for scientific control if a satisfactory finished product is to be obtained It cannot be too strongly stressed that in ordering materials a full specification should be given. Tests should then be carried out during the whole course of the work to ensure that the makers are adhering to the specification This can be done in the laboratory of a County or Borough, or for smaller areas there are a number of very competent Testing Laboratories whose charges are amply repaid by the improved quality of both material and workmanship. If the Authorities concerned insist on these tests the contractors in their turn will have to establish stricter control than formerly Good firms have already realized the need for control and many have a laboratory at all their manufacturing plants, samples are also taken from the work during construction This practice must be general if a first quality product is to result The contractor is required to bear the cost of all unsatisfactory tests, to take up material not conforming to specification, and relay the correct product at his own expense

Often too little attention is paid to the maintenance of roads but frequent inspection and early repair of the damage can save very large capital expenditure.

ROUTINE CARE AND MAINTENANCE

It is an unfortunate fact that a modern road may fail as much from lack of traffic upon it as from heavy usage. To the uninitiated this is a difficult statement to explain but it is certainly true, particularly with tarred macadam and cutback bitumen surfaces

In the following pages the maintenance of the more commonly used surfacings will be considered

CONCRETE

Complete failure of a concrete road may be due to a number of constructional faults but the most general cause is the access of water to the subgrade through the joints The percentage increase in moisture content required to cause failure is very small indeed. In one reported instance an increase of only 4 per cent was sufficient Further, the lodging of foreign material in the joints at low temperature may cause spalling when the temperature rises Although many joint fillers are on the market, none as yet fulfils all the requirements of the perfect joint and consequently continuous maintenance is necessary. It is not sufficient to trim off the jointing that has spewed out. The joint should be thoroughly hacked out to a depth of $1\frac{1}{2}$ to 2 in , well brushed and then resealed. If it is to be done properly without damage to the slab the hacking out is quite a skilled job. If the work is carelessly done

FIG. 1.—SURFACE FAILURE DUE TO SATURATED SUB-BASE

FIG. 2.—VIBRATING MECHANISM ATTACHED TO SMALL PLATE

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the difficulty of resealing the joint in a satisfactory manner is greatly increased. Some jointing materials extrude very much less than others and careful consideration of fillers is worth while. The practice of leaving the finished level of the joint ⅛ to ¼ in. slack according to season has much to commend it.

Where contraction cracks occur the crack should be cut out to ¼ in. wide and at least ½ in. deep, and sealed as before.

On many older concrete roads there is a joint between the kerb and the road, in the channel. If this condition is met it is recommended that the joint be filled with bituminous sand grouting material and a false channel thus made some 2 to 3 in. out from the kerb. This will prevent water lodging over the weakest part of the roadway.

Patching of concrete is often difficult. A small patch can be made by trimming back to a rectangular shape with rounded corners. The existing concrete should be trimmed with the side vertical, and the surface left rough. If the slab has been reinforced a lap of at least 1 ft. in all directions between existing and new reinforcement should be aimed at. The surface of the existing concrete should be well brushed to remove dust and then wetted, and finally coated with cement slurry prior to placing new concrete. This latter should be well tamped. The German type of hand vibrator illustrated in Fig. 2 can be used to good effect for small areas. If patching is required over a service trench it is important to ensure good bearing for the new concrete on undisturbed ground on each side of the trench.

Greater strength can be obtained by increasing the thickness over the trench below the slab or other metalling as shown in Fig. 3.

The thickness of a patch not over a trench should be 1·3 of the thickness of the slab for edges and 1·2 of the thicknesss of the slab for central patches.

In addition, it is hardly necessary to stress the undesirability of a joint in the finished surface occurring immediately over the trench. Greater care in the compaction of the back filling is very desirable and with modern plant it should be possible to obtain a finished density of fill which closely approaches the density of the natural soil.

Where unequal settlement occurs at the edges of slabs, mudjacking will sometimes correct the trouble. Expert advice is required before this is undertaken.

WATERBOUND MACADAM

Except in rural areas, little of this type of road construction remains exposed. For modern requirements it serves as an excellent base for a carpet coat as the thickness of road metal is frequently up to 2 ft. and more in thickness. Repair where required can best be made with a weak concrete of 12:1 mix. This avoids the necessity of rolling or heavy punning which is required if the normal aggregate and slurry patch is made. It is very difficult to compact the latter material satisfactorily if the road has been surfaced. Even on a road which has not been surfaced the repairs are more easily carried out in tarred macadam or concrete, care being taken first to brush the surfaces free of dust and then coat with tar or bitumen emulsion as a tack coat, or a cement grout.

If, however, the road is repaired with waterbound macadam it is very desirable that the patch

should be filled with the same materials as used in the original construction.

Calcium chloride if sprayed on the surface helps to lay the dust for a period and also helps to bind the surfacing material.

SETT PAVING (INCLUDING GRIT SETTS, DURAX, GRANITE SETTS).

The need for maintenance arises mainly from two causes: (1) the rounding of the edges of the setts and (2) settlement due usually to the movement of the sett or failure of the jointing material, which consequently allows water to obtain access to the sand bed.

The treatment of (1) is by reconstruction or surfacing. The setts must be taken up and can either be redressed or frequently, if the sett is inverted a good face can be obtained. The setts are re-bedded in 1 in. of sand or clean ashes, racked, rammed, back racked and grouted with a hot bituminous mixture. Alternatively the grouting can be done with a cement grout, or pitch.

For (2) relaying must again be done as above, and care should be taken to remove the wet sand bed before the setts are relaid. If bitumen is used the chippings should be dry before grouting.

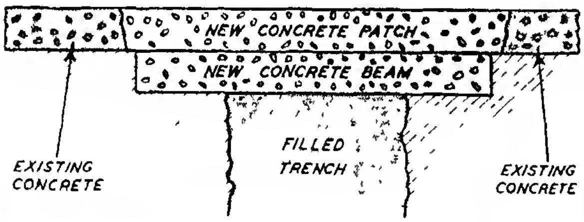


FIG. 3.—PATCHING OF CONCRETE ROAD

FIG. 4.—SURFACING LAID ON HARDCORE WHICH HAS BEEN LAID ON WET SUB-BASE

Generally where a sett-paved road requires maintenance this can best be done by superimposing a 2 in. carpet coat of tarred macadam or asphalt if this does not involve creating excessive camber or cross fall. Where carpet coating is adopted the setts immediately adjoining the kerb should be lowered in order to avoid the necessity of altering footpath and gully levels, etc. Alternatively, a less satisfactory job may be made by dishing the surfacing at gullies; a better method is to raise all gullies and manholes to the new level.

WOOD BLOCK PAVING

To an increasing extent wood block paving is being replaced or surfaced with tarred macadam and asphalt, although very large areas of wood blocks still remain in many parts of the country and are being relaid—notably in London.

Once laid the maintenance of wood blocks consists of surface dressing. This tends to prevent uneven wear, stop contraction of the blocks, and gives a non-skid surface, at the same time immeasurably increasing the life of the paving. Surface dressing also tends to reduce the displacement of the blocks caused by fast-moving traffic. Occasionally the wood paving lifts after dry weather in spite of all precautions and there is then no alternative but to cut out and relay.

Failure of surface dressing is usually attributable to poor materials or workmanship. Even a neglected block-paved area can be given a new lease of life if careful surface dressing is carried out. Under certain conditions considerable expansion of the blocks takes place and unless this is relieved, for example, by taking out a course of blocks immediately adjoining the kerb, the road surface will lift or the kerb will be displaced. When the blocks are removed they should be replaced with bituminous joint filler or puddle clay sealed with bitumen. Over very wide roads an additional stringer course of blocks may be laid which can be removed if excessive expansion takes place.

If hollows occur in the paving due to variability in quality of the wood, the area should be cut out and replaced or alternatively patched with asphalt and surface dressed. Such low spots form a collecting point for water which will ultimately find its way through to the bed below the blocks. When this happens failure can take place over a wide area. Owing to the variation in size and characteristics it is desirable that any patching of the area should be carried out with the same type of block as that which is removed.

It is often necessary to refloat the concrete surface below the blocks before they are relaid

thereon (See also separate article on Wood Paving, page 203.)

Tarred Macadam

Failure of a tarred macadam surface can be attributed mainly to two causes: (1) Movement of the sub-base and (2) Lack of maintenance.

Movement of the foundation.—If hardcore is placed on a plastic subgrade, movement will occur and no amount of rolling will compact the hardcore until the subgrade has dried out. Tarred macadam surfacings have been laid on foundations which are live but generally where such conditions obtain it is difficult or impossible to compact the surfacing and even if this is done, apparently satisfactorily, the surface will be uneven and small hair cracks will occur. It is then only a matter of time, frequently short, before complete failure takes place. (See Fig. 4.)

Lack of Maintenance.—In selecting a surfacing, all too little attention has been paid in the past to obtaining a correct grading. Whatever range is chosen it is essential on a hardcore base to ensure that the finished job is impervious. This having been achieved, it is of primary importance that it should be maintained, and it is frequently overlooked that lack of traffic on a tarmacadam road may be more detrimental than heavy traffic. If water finds its way through the surface, movement of the hardcore will quickly follow, due to disintegration of the subgrade, and immediate reconstruction of the affected area must be undertaken.

Not only must the affected area be treated, but the source of the trouble must be located. Failure of the road at a given point may not be due to penetration of water at that point, but the water may find its way through the carpet at a place higher up the longitudinal gradient. The failure of a tarred macadam runway was recently investigated and it was found that failure occurred on the haunch, at places where the carpet was impervious. It was clear that water was finding its way in at pervious areas on the crown, travelling through the base course and causing failure at the haunch. In other words, it may be necessary not only to patch at the point of failure but also to treat the adjoining area through which water is entering.

Frequently lack of traffic, for example on an estate road, may leave the surface under-compacted. The action of the elements may then cause the surface to fret, thus breaking the seal. Where this is likely to happen the surface must be sealed by an apparently unnecessary tar spraying.

It is the practice of some Highway Authorities

Fig. 5.—Typical Failure of Hardcore and Tarmacadam Patch

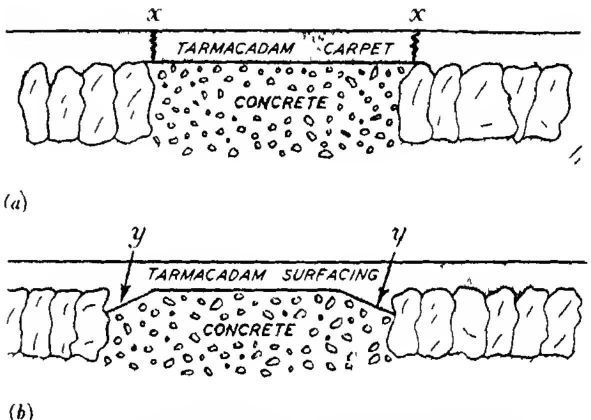


Fig. 6.—Two Methods of Patching Tarmacadam using Concrete in Place of Hardcore

when a new tarred macadam surface is being laid to include in the bill a P.C. item for tar-spraying the newly-laid surface at some prescribed time after the work is finished, say six months to a year. This practice has much to commend it, as even with three-coat work there may be small areas which are slightly pervious, particularly after severe winter weather.

Repair.—If the failure is due to movement of the base course the area must be removed to full depth including the affected subgrade. This can be replaced using hardcore but for small areas the difficulty of compacting the hardcore and tarred macadam then arises. A typical failure is shown in Fig. 5. During the past few years, very satisfactory results have been obtained using concrete in place of hardcore for the patch. Originally the hole was filled flush as shown in Fig. 6*a* but it was found that after fairly heavy use by traffic a crack occurred at *x* in the finished carpet, due to the comparative rigidity of the concrete as compared

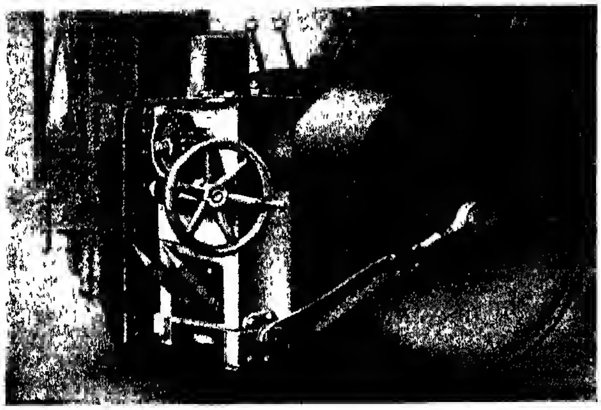


FIG. 7.—SCARIFIER TYNES ATTACHED TO DIESEL ROLLER
(*Aveling-Barford, Ltd.*)

FIG. 8.—TYPICAL CONDITION OF BASE BELOW PREVIOUS CARPET

with the hardcore This was overcome by chamfering the edge of the concrete as shown in Fig 6*b* The extra thickness of tarred macadam at the point *y* had a cushioning effect and although some patches of this type have been down for several years, no cracking has been observed

The main method of maintaining tarred macadam is by tar-spraying No definite lapse of time can be given as to when this should be carried out It must vary with the weather conditions, usage of the road, and whether or not the surfacing appears hungry. Generally the period will vary from one to three years, and in some instances even longer periods are known.

Tar-spraying over a long period tends to accentuate the camber of the road to such an extent that, in extreme instances, it may cause physical discomfort to the users When this happens, resurfacing should be undertaken The existing surface should be scarified by means of tynes attached to a roller (see Fig. 7) These can be adjusted to cut the surface to the required depth The number of tynes that can be used will depend upon the hardness of the carpet Such scarified material as is not required is carted away, the remainder is used to re-form the road to camber, treated with a tack coat, and then surfaced (See page 406 for carpet coats.)

Patching.—Potholes should be cut out to a rectangular shape and vertical face using a pick or pneumatic breaker. If the carpet only is damaged the hole need not be cut to the full depth of the surfacing but it is frequently found that the base-course has suffered, in which case it may be either removed or loosened, given a dressing of emulsion or tar and then well rammed. After this the carpet coat is renewed over the area. The carpet should be of the same type of material as the existing surface.

Some authorities leave the finished level of the patched area proud of the surrounding area but experience suggests that where the repair work has been well done this is both undesirable and unnecessary

It is generally an advantage to use material which has a binder of cut-back bitumen (300 to 400 secs at 25°C) or low viscosity tar (viscosity 20 to 40 at 30°C) as the patching material can then be laid cold If, however, quicker setting binders can be used they are greatly to be preferred

At the present time the repair gang usually has to work with a roller, and in some areas a heavy roller is considered essential This is obviously uneconomical and a small hand roller is now being manufactured (see Fig 12, page 323) which can be used with or without the vibrator The results obtained are as good as those achieved with a heavy roller, and the small machine is easily transported and handled.

Ravelling—This consists of the disintegration of the surface into loose material If this is far advanced it can only be repaired by scarifying, applying binder, recompacting and chipping or resurfacing In the early stages ravelling can be treated by applying a dressing of emulsion, rolling or punning and then dressing with fine tarmacadam or precoated chippings

ASPHALT

The general maintenance of asphalt surfaces is by patching and tar-spraying. Patching is carried out in a similar manner to that used for tarred macadam, except that it is an advantage to use a road burner, if available, for removing the existing surface (see Fig. 9), otherwise pneumatic breakers are necessary, though small areas can be removed or trimmed with hammer, wedge and pick.

The sides of the patch are trimmed square, cleaned and tack coated before the new material is laid. The specification given in B S 1152 1944 is recommended for patching of small areas

It is an advantage if hot material can be used Mastic asphalt heated in a mobile road boiler is excellent for this purpose The final surface can be rendered non-skid by rolling in precoated chippings while the mastic is still warm

Alternatively quite a good cold bituminous patching material can be made by mixing $\frac{3}{4}$ in to $\frac{1}{8}$ in stone with cut-back bitumen or tar at the rate of 1 gallon of tar to $1\frac{1}{2}$ to 2 cu ft of stone

RESURFACING

A surfacing is defined as layers or coats of road metal incorporating a binder and laid on a base in such a manner as to form a pavement of sufficient strength to carry the expected intensity of traffic It should give a smooth running surface, at the same time acting as a cushion to the base and affording protection to the subgrade and base against abrasion and the effects of the weather

In the life of any bitumen or tar road a time will come (usually after 10 to 15 years' use) when normal methods of maintenance are no longer economical and more extensive works have to be undertaken This entails the removal of the existing surface and the reshaping of the road

In considering surfacings it is presupposed that the foundations are uniformly good If this is not so patching and draining must be undertaken to bring the whole base-course and subgrade up to a uniformly satisfactory standard

Removal of Existing Surface

Asphalt—The removal of the existing surface is carried out by burning of the surface and removing the burnt material with rakes The chief disadvantage of this method is that it is slow, and can only be used if the depth of material does not exceed about one inch. If the depth exceeds one inch it is desirable to use a scarifier or in some cases pneumatic road breakers

Tarred Macadam—This material can be quickly removed by the use of a scarifier and tynes attached to the rear of a heavy steam roller The number of tynes that can be used depends upon the depth of cut required, the condition of the existing surface and the size of roller used

Reforming Base-Course

It is usually found that after part of the surplus scarified material has been removed, some can be retained for reforming the base-course and taking out any irregularities that exist This material is spread and compacted true to profile at a depth equal to the thickness of the surfacing below finished level If the life has gone out of the material to be re-used it is advantageous to grout the reformed areas at, say twelve yards per gallon, using cold-emulsion or tar [see B S 618 1935—"Emulsions of Road Tar and of Road Tar-asphaltic Bitumen Mixtures (grouting and semi-grouting) and Surface Dressing"]

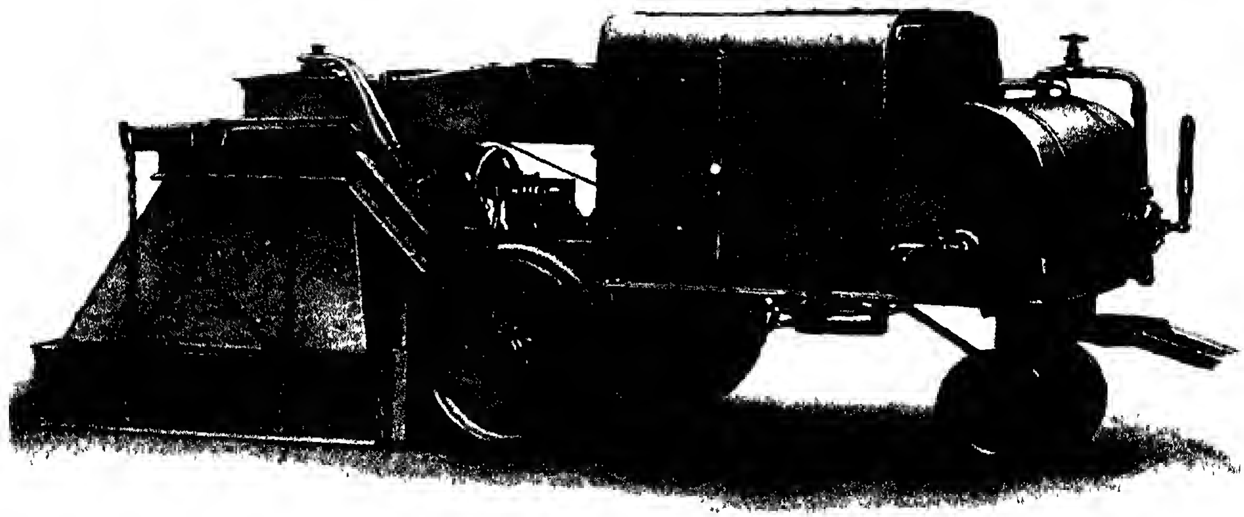


Fig 9—"Quickfat" Road Heater

(Johnston Bros. [Contractors] Ltd)

The whole area should be well rolled, as it is possible that the base-course has been disturbed by the removal of the surfacing. This is particularly so if scarifiers have been used.

Choice of Surfacing

The essential qualifications of any surfacing are that it shall be waterproof and shall be of sufficient thickness to withstand the traffic that is likely to use it, transmitting the load to the base without undue deformation (see Fig. 8).

Secondary considerations are that it shall be durable, that is, it should have long life under the traffic likely to use it and not be subject to the weather. At the same time maintenance cost should be low, but initial heavy cost is often warranted by subsequent saving in maintenance.

The surfacing should be sufficiently flexible to take up slight movement of the base without fretting or cracking but must not be so plastic as to creep under traffic or bleed in hot weather. Freedom from dust is important particularly in built-up areas, and the need for a non-skid surface under all conditions of traffic and weather does not need to be stressed. At the same time if the surface is very rough an excessive camber may be needed to get the water away and the "cure" may be worse than the "disease".

Opinions differ greatly in various parts of this country as to the best type and thickness of surfacing to be used. Economy is most frequently a ruling consideration, and on these grounds a surfacing using local materials has great advantages. As regards thickness, this may vary from 4 in. thick three-coat work to $\frac{3}{4}$ in. of asphalt or tarred macadam on a concrete foundation. This latter is really a carpet and will be considered later.

A formula has been developed by R. Vokac of America for determining the thickness of a surfacing which depends on the shear strength of the surfacing material. At present this is a theory without much practical support, but if this latter is forthcoming a considerable saving in the thickness at present adopted for many roads will doubtless be possible.

SPECIFICATIONS FOR TARRED MACADAM SURFACING

There are a number of excellent proprietary tarred macadam products on the market, which can be laid with confidence and whose makers are frequently prepared to give a maintenance guarantee with their product. As an example, a mile stretch of very heavily trafficked factory road laid in the Midlands over three years ago using a proprietary material is still in first class condition although it has not received any maintenance. This surfacing was guaranteed for two years at the time of placing of the contract; equally satisfactory results have been obtained with other similar materials.

It is not, however, necessary to use proprietary products to obtain good results. In the main, results are achieved by good materials and careful attention to grading.

Choice of Binder

B.S. 76: 1943—"Tars for Road Purposes" revises the previous B.S. of 1930 and 1931 and embodies all the latest improvements of thirteen years. Tars A, B, and C do not correspond to the old types 1, 2 and 3, which were all of a type corresponding to the present type A. A new method of gauging viscosity is introduced—the Equi-Viscous Temperature (E.V.T.). This is the temperature at which a tar has a flow of fifty seconds measured by the standard tar viscometer. Generally this B.S. narrows the limits for a good road tar and excludes unsuitable tars.

The main differences now are:

Type A.—Contains the highest proportion of lower boiling oils and is particularly suitable for surface dressing and for the manufacture of tarmacadam.

Type B.—Contains a lower proportion of the lower boiling oils and is particularly suitable for both carpets and tarmacadam.

Type C.—Is a special material and is generally suitable for carpets containing a low proportion of fines.

B.S. 76 lays down in Table I the variations necessary for viscosity for summer and winter use and also for the volume of traffic using the road. The selection of the correct viscosity and type of tar for a particular job can make the difference between success and failure in the finished product and consequently is worthy of most careful consideration.

For specification purposes it is sufficient to quote B.S. 76 and give the type of tar and E.V.T. required. B.S. 802 and 1241 recommend the types of tar and the E.V.T. for the main aggregates used in the manufacture of tarmacadam.

Grading and Choice of Aggregate

In choosing aggregate, economy can be effected by the use of local material available, but care should be taken to avoid weathered aggregate.

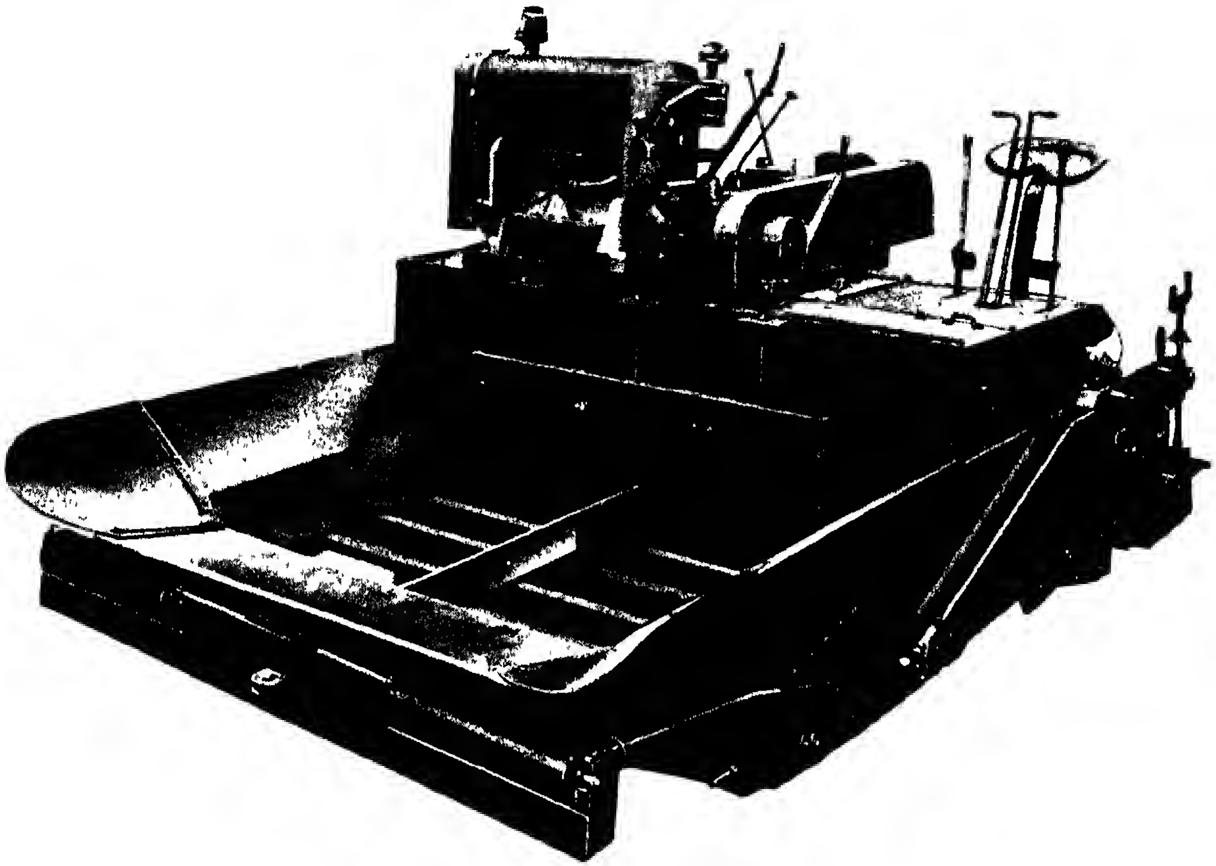


FIG. 10.—BARBER-GREENE SPREADER AND FINISHER

(Jack Olding & Co., Ltd.)

Rapid failure of a surfacing can take place if even a small percentage of this is included. Failure will begin as soon as the stone becomes exposed, and is evidenced by the apparent ravelling of the surface.

The desirable grading is given in B.S. 802 and 1241. In choosing the grading for a particular job the thickness of the coat must be considered. It has been found, for instance, that for a 1 in. coat ¾ in. material is too large, as some of the aggregate may be longer than the thickness of the carpet and this facilitates ultimate porosity. Alternatively too dense stone mixtures tend to keep the tar soft and the material live.

Slight variation in the colour of a road surfacing can be obtained by selecting coloured aggregate, both for the tarmacadam and for surface dressing.

Mixing

It is recommended that the mixing be continued until all particles are thoroughly coated and for not less than one-and-a-half minutes. Prolonged heating of the material will tend to drive off the more volatile tar oils and may seriously affect the quality and viscosity of the tar. Overheating of the mixture may result in the material being burnt. In the more advanced state this condition is not difficult to identify in the finished product, as it appears dull and lifeless, and has a hungry appearance when laid.

Spreading

For small areas this may be done by hand, using heated forks and rakes. If, however, the area to be covered is large (usually over 10,000 yards) a mechanical spreader and finisher is the most satisfactory and economical way of carrying out the work. It must be remembered that this plant, an example of which is shown in Fig. 10, spreads at uniform thickness regardless of

irregularities in the existing surface, which must consequently be removed by hand as the work proceeds, or be removed before the work is started. The former is usually a less expensive and more satisfactory method.

Sampling and Testing

The desirability of sampling and testing is stressed in all relevant British Standard Specifications (B.S. 616 : 1938, Sampling Coal Tar and its Products, and B S 598 1940, Sampling of Bituminous Road Mixtures) This is a wise precaution with any material and the number of tests must depend on the size of the job At least one test on a job of any size is desirable and on a large job a sample every ¼ mile is not excessive. The testing presents no serious difficulty, as samples can be dispatched by rail to one of the recognized Testing Laboratories The cost entailed is very small relative to the job, and the increased control which such testing makes possible is more than recompensed by better quality of the mix and more uniform grading of the material as laid

BITUMINOUS SURFACING

The preparation and use of this material has been very extensively covered by British Standard Specifications as follows.

- B S 347 : 1928 Asphalt macadam (Penetration Method) add 1930
- B S 433 · 1931 Cold Asphalt macadam (Grouting and semi-grouting) Penetration method using road emulsion
- B S 434 1935 Asphaltic Bitumen Road Emulsion for Penetration and Surface dressing
- B S 510 . 1933 Single-coat Asphalt (Cold Process)
- B.S. 511 : 1933 Two-coat Asphalt (Cold Process)
- B S. 594 : 1935 Rolled Asphalt Fluxed Lake Asphalt and Asphaltic Bitumen
- B S. 595 . 1935. Rolled Asphalt. Fluxed natural and Asphaltic Bitumen.
- B.S. 596 : 1935. Mastic Asphalt Surfacing (Fluxed Lake Asphalt and Asphaltic Bitumen)
- B.S. 597 . 1935 Mastic Asphalt Surfacing (Fluxed natural Asphalt and Asphaltic Bitumen).
- B.S 598 : 1940. Methods of sampling and Examination of Bituminous Road Mixtures
- B S. 618 1935. Emulsions of Road Tar and Road Tar-Asphaltic Bitumen mixtures for Penetration and Surface dressing.
- B S. 1152 : 1944. Rolled Asphalt

Probably the most generally useful of these specifications for road schemes is B S 1152, Rolled Asphalt, as it provides for the use of aggregates of a wider range and variety than those in general use in pre-war days

As with tarmacadam it is beneficial on a large job to use a mechanical spreader, finishing with a roller of the quick reverse type If hot material is laid rolling should be continued until the material has set With a cut-back this cannot be done and instructions should be given to re-roll the material until the asphalt has set, to take out any irregularities caused by the traffic

A typical specification clause is suggested as follows

> "It may be accepted that although this surfacing, using cut-back bitumen, will withstand the loads due to rolling or stationary traffic, it will be damaged by traffic making a sharp turn or braking suddenly, also by solid-tyred traffic, for a period up to four weeks after laying The damage will consist of deformation or tearing of the surface and allowance should be made for rolling the material back to its original contour should this be needed during the above-mentioned period "

Transporting

It has been found desirable to limit the distance over which the hot mix material can be transported, from the mixing plant to the site, to thirty miles and even for this distance care has to be taken against overheating the mix If this distance is exceeded cut-back bitumen should be used in place of straight-run. Doubly-sheeted metal-lined lorries are also frequently specified As a very rough guide the loss in temperature during transport may be taken as approximately 1° of temperature per mile transported.

Tack-coating

If the surfacing is to be laid on concrete or an existing surface a tack coat of 55 to 65 per cent bituminous emulsion is recommended prior to laying, and on concrete this may be used at the rate of 12 sq yds per gallon. On other surfaces

the rate of spread may have to be increased, particularly if the existing surface is dead, when 6 to 8 sq. yds. per gallon may be needed

MIXING

The top limit of temperature specified for the mix should be strictly adhered to and will normally only be needed if a long haul is inevitable If in exceptional circumstances the material is not completely dry, coating of the damp aggregate will be aided by the addition of 1 to 2 per cent (by weight of aggregate) of hydrated lime, before the binder is incorporated This should be thoroughly mixed with the aggregate before the binder is added

LAYING

The laying temperature recommended is 200°F but if it is necessary to raise the mixing temperature in order to attain 200°F on site it is usually wiser to reduce the laying temperature, provided a minimum of 150°F is observed Instances are reported in which a material laid at 130°F has been satisfactory but this is not to be recommended

As a check on coverage of the material, the rate of spread per ton is frequently specified As a guide a 1 in textured carpeting may be expected to cover approximately 22 sq yds per ton A roller of minimum weight 6 tons is recommended; for coarser grading, e g, base coat, a heavier roller of 8 tons minimum will give improved results The weight of the roller should not, of course, exceed the weight of the roller used in compacting the base

TESTING

It has been found that the expense of frequent sampling and testing of the laid material is well repaid This is carried out in accordance with B S 598 : 1940 In the case of contract work it may be required that "The testing will be carried out by an independent firm of approved testers All material not up to specification shall be removed and relaid at the contractor's expense and he shall also bear the cost of tests on material proved to be substandard"

CARPET COATINGS

In selecting a carpet the following points should be considered apart from cost:

1. Imperviousness.
2. Smooth riding qualities.
3. Resistance to skidding without excessive tyre wear.
4. Durability and freedom from maintenance.

1 *Imperviousness* can only be obtained by very careful attention to grading Much consideration has been given to this subject in connection with the mixing of asphalt carpets but only comparatively recently has similar attention been given to tarmacadam The grading should be based not only on particle size of the aggregate but also on the shape and type of the aggregate, e.g rounded gravel aggregate would require more sand and filler than more angular material If the material is to be laid on a flexible foundation it must be impervious immediately after placing and rolling If, however, the carpet is to be laid on concrete or other impervious base this is not so important and a more open-textured material which will allow for further compaction under traffic without loss of texture can be used At the same time excess of binder is very undesirable and the difference between good binder content and excess may be as small as 0 75 per cent in the case of a dense carpet

2. *Smooth riding qualities* of a carpet depend largely on the evenness of the base on which the carpet is laid and control at the time of laying In this connexion skilful spreading and rolling is of first importance Excess of binder and filler, that is, a particularly fatty mix, are also contributory causes of unevenness

3 *Resistance to Skidding* depends not only on the proportion of coarse aggregate but also on the correct grading of filler and binder and type of aggregate used, e g. limestone tends to give a more slippery surface This quality is to some extent the antithesis of (1) but by careful selection it is possible to obtain a carpet which satisfies both requirements In some instances where the surface is already waterproof a carpet may be laid to obtain a non-skid surface If this is required an open texture carpet which is pervious will meet essential requirements A densely graded carpet of the mastic asphalt type can be made non-skid by rolling in pre-coated chippings. This requires care on the part of the foreman, for the chipping, if done at the wrong temperature, will not remain in position under traffic With good workmanship the chippings have remained in position for more than four years

4. *Durability and low maintenance costs* depend to a great extent on the selection of the correct grading, quality of aggregate, and upon close control to ensure conformance to specification. For example, excess binder content is as undesirable as too low a binder content, since consequent bleeding requires maintenance On a main road this is important as all maintenance will cause dislocation of traffic to a greater or lesser degree.

TABLE I

SPECIFICATION FOR 1-INCH CARPET

Sieve Size Grade	*Percentage by Weight*
Passing $\frac{3}{4}$ in in B.S Sieve	100
Passing $\frac{1}{8}$ in in B.S Sieve	45–55
Passing 13 mesh B S Sieve	25–45
Passing 200 mesh B S Sieve	5–6

Generally the British Standard Specifications envisage the use of a thicker carpet than is now considered necessary, particularly as regards bituminous carpets

To meet this need the British Standards Institution have published Specifications 802 : 1945 and 1241 · 1945 and the Road Research Laboratory has published "Wartime Road Note No 7 Revised Recommendations for Tar Carpets" which gives details for the manufacture of tarmacadam with the most commonly used aggregates Unfortunately doubt is expressed in the B S Specification as to the manufacturers' ability to produce the specified material at the present time (to be reviewed at the end of 1946), and whilst a number of tarred macadam firms could exercise the necessary controls a number could not, and only insistance upon the B S., supplemented by careful checking of laid material will bring them into line.

Recommended gradings are shown graphically in Fig 11.

At the present time a carpet is frequently laid to a thickness of ½ to 1 in.

For many years prior to the war Road Engineers used carpets supplied by one of the many reputable makers using both tar and bitumen as binders and very satisfactory results have been obtained, but the Engineer usually had no knowledge of the composition of the material he used and consequently had little or no control of the finished product. Fortunately the firms concerned were aware of the need for close control of the mix and grading, and did their best to ensure that a uniformly good product was manufactured and laid under their trade name.

In selecting a carpet it is becoming increasingly necessary to consider the volume and type of traffic likely to use a road and to vary the grading accordingly. A good mix for a country road will not necessarily meet the needs of a heavily trafficked city street and hence there are good reasons for ceasing to use a standard product, the grading of which is unknown

The Road Research Laboratory has tests in progress on some seven hundred trial sections of carpet on the Colnbrook By-pass and the results of these tests after two years' duration only are reported in the Journal of the Institution of Civil Engineers of November 1941. (*Slater on Road Experiments on the Design of Thin Bituminous Surfacings*) The experiments were carried out on gravel and granite, using tar and bitumen as binders. Results obtained from carpets using quartzite, slag, limestone and whinstone laid in 1937 and 1940 are also discussed. Generally gravel was found to be the most difficult material to use satisfactorily and it was also found that if bitumen is used as a binder, a greater range of design is possible The whole question is discussed more fully than space here permits and reference to this paper is recommended, although it is not suggested that the results at the date of publication of the paper are in any way final.

A specification for 1 in carpet at present giving excellent service in many parts of the country after being down for three or more years is given in Table 1

This was found satisfactory for fairly heavily trafficked aprons and factory roads using a cutback bitumen (180 to 220 Penetration in the summer or up to 300 Penetration for winter work); at the same time straight run bitumen was preferred wherever possible The percentage bitumen used was 5 5 to 6 5 per cent by weight of the mixture. A type A tar to B S. 76 : 1943 may also be used as binder.

In specifying the laying temperature of hot laid material for carpet work the cooling effect of the base on which it is to be laid must be considered.

TACK COATS

It is desirable to lay a tack coat on concrete or similar base before laying a carpet. The tenacity of such a tack coat is surprising, as can be seen if inferior material has unfortunately to be removed. A spray of 55 to 65 per cent bituminous emulsion at 12 yards per gallon is recommended. It is also desirable to specify the viscosity required as this is by no means entirely dependent on the bitumen content.

SURFACING SETTS

Although thin carpets have been laid on setts these are not generally satisfactory except for very lightly trafficked roads. For a lasting job on most roads a minimum of 2 to 3 in. of surfacing material is required.

USE OF GRADING CURVES

The curves are plotted from the tables given in the various specifications mentioned. Whilst the grading of a particular aggregate may fall within the upper and lower limits given in the tables it can still be an unsatisfactory grading if the shape of the curve is irregular This was illustrated on a runway scheme where the base course and surfacing were unsatisfactorily graded although they were within the upper and lower limits of the specified table, and the utmost difficulty was experienced in persuading the contractor to vary the specification once the work had begun

The sieve analysis of the aggregate which it is proposed to use is plotted on the logarithmic graph and if it is satisfactory will be found to fall within the upper and lower limits drawn for the particular grading As already mentioned this alone is not sufficient, as the grading curve should also have a good shape if the final grading is to be satisfactory If the shape of the curve for the suggested aggregate is irregular it will be necessary to increase or decrease the various sizes of aggregate until a satisfactory shape is obtained In making this adjustment it is obvious that any increase should be made in the size of aggregate which is most readily available

The easiest method to use is to plot the sieve analysis of the proposed aggregate on tracing paper and place over the required curve here shown It can then be seen if this curve falls within the recommended limits for the material specified and, if not, a good idea can be obtained of the points at which adjustment is required

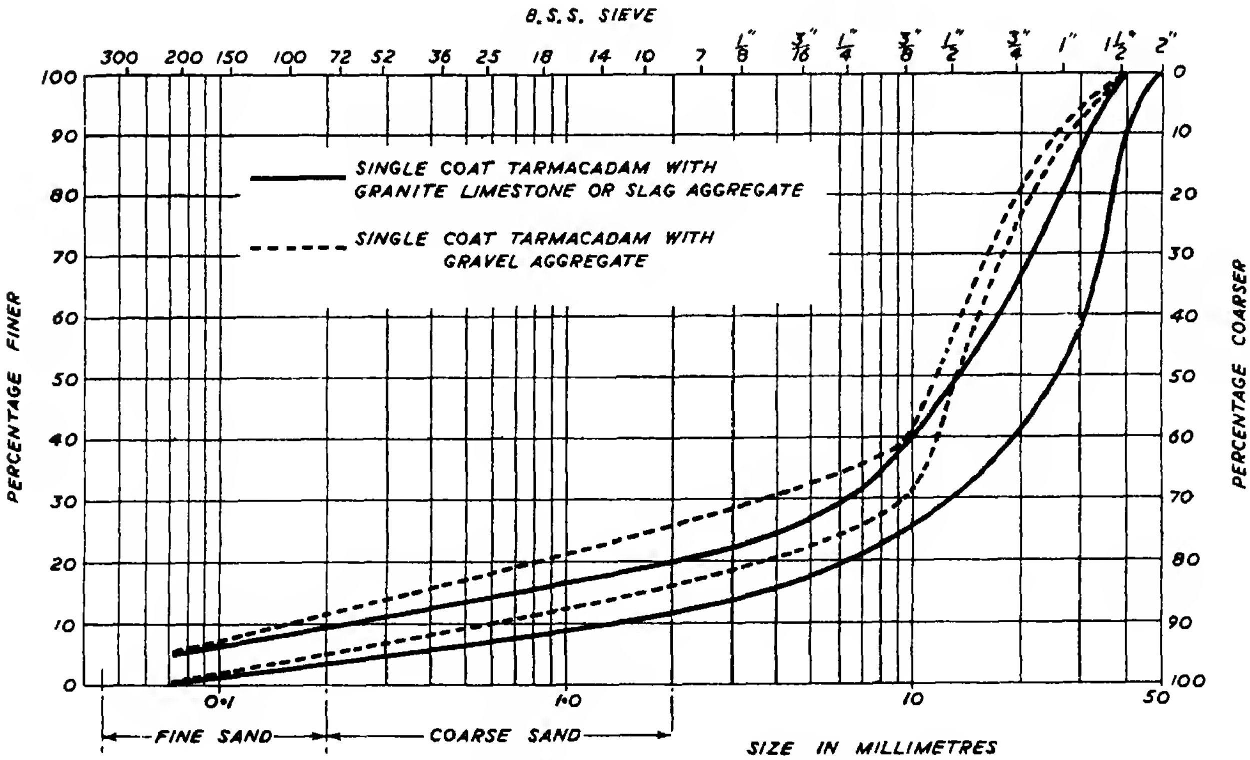


FIG. 11a—MODEL SPECIFICATION FOR ROADS

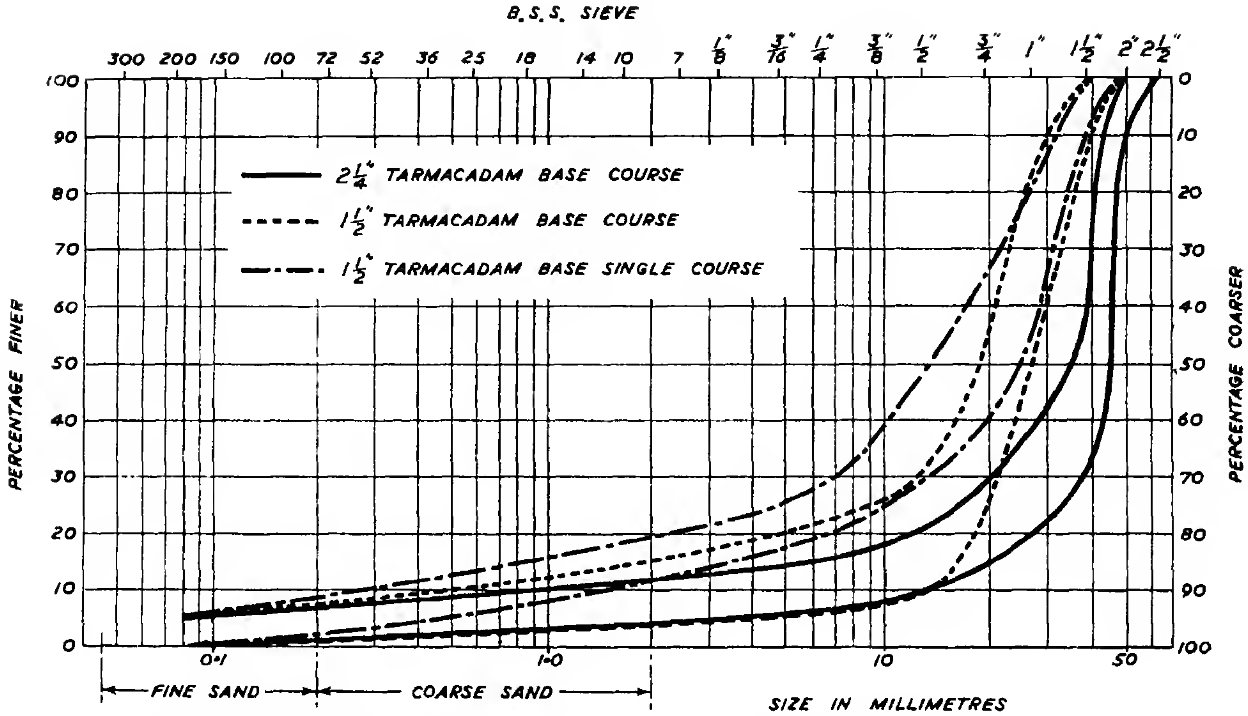


FIG. 11b GRADING RECOMMENDED IN B.S. 802, TABLE I, FOR GRANITE LIMESTONE AND SLAG AGGREGATE

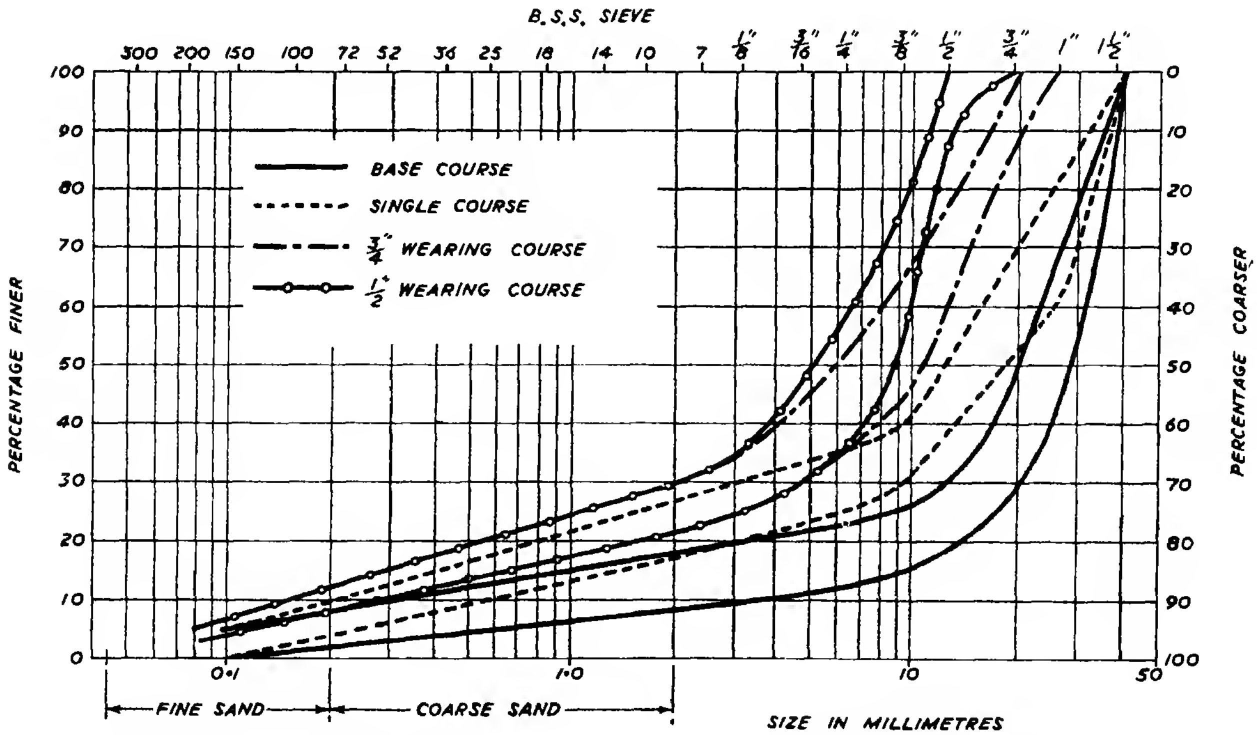


FIG. 11c—GRADING RECOMMENDED IN B.S. 1241, TABLE I, FOR GRAVEL TARMACADAM TO BE LAID WARM

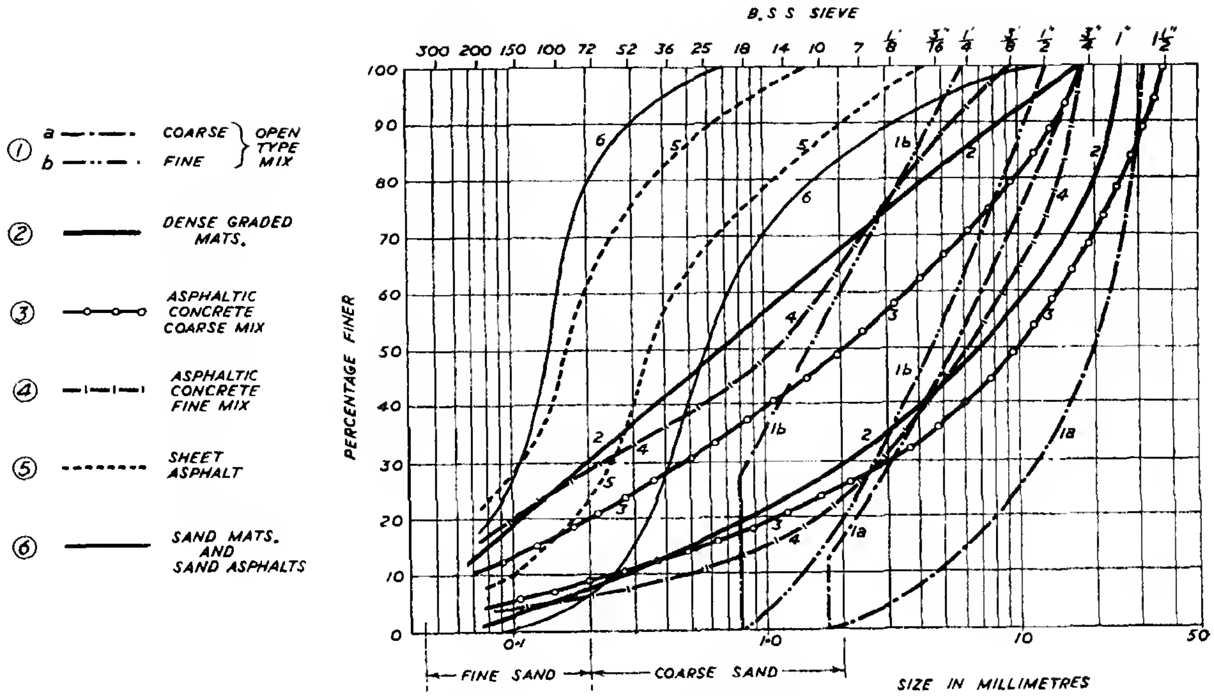


FIG. 11d.—SOME SUGGESTED GRADING CURVES FOR BITUMINOUS PAVING MIXES

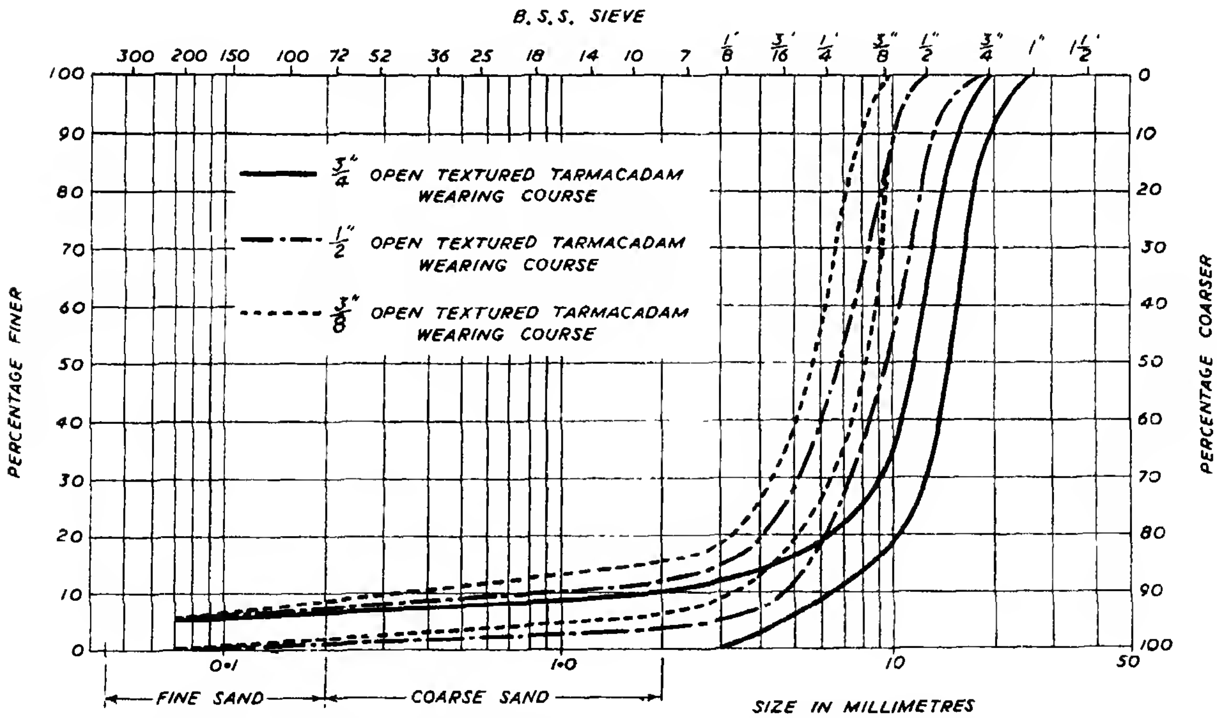


FIG. 11e.—GRADING RECOMMENDED IN B.S. 802, TABLE II, FOR GRANITE, LIMESTONE AND SLAG AGGREGATES

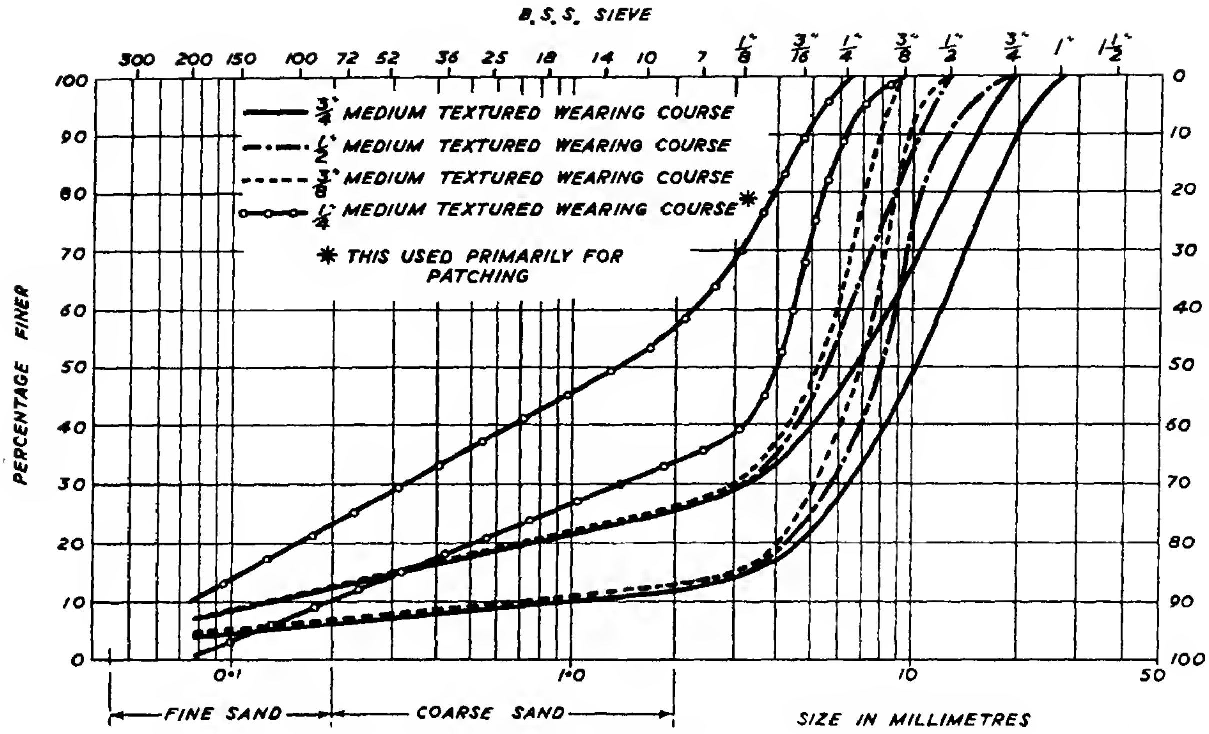


FIG 11f—GRADING FOR MEDIUM-TEXTURED WEARING COURSES, PREFERABLY LAID WARM, B S 802, TABLE III

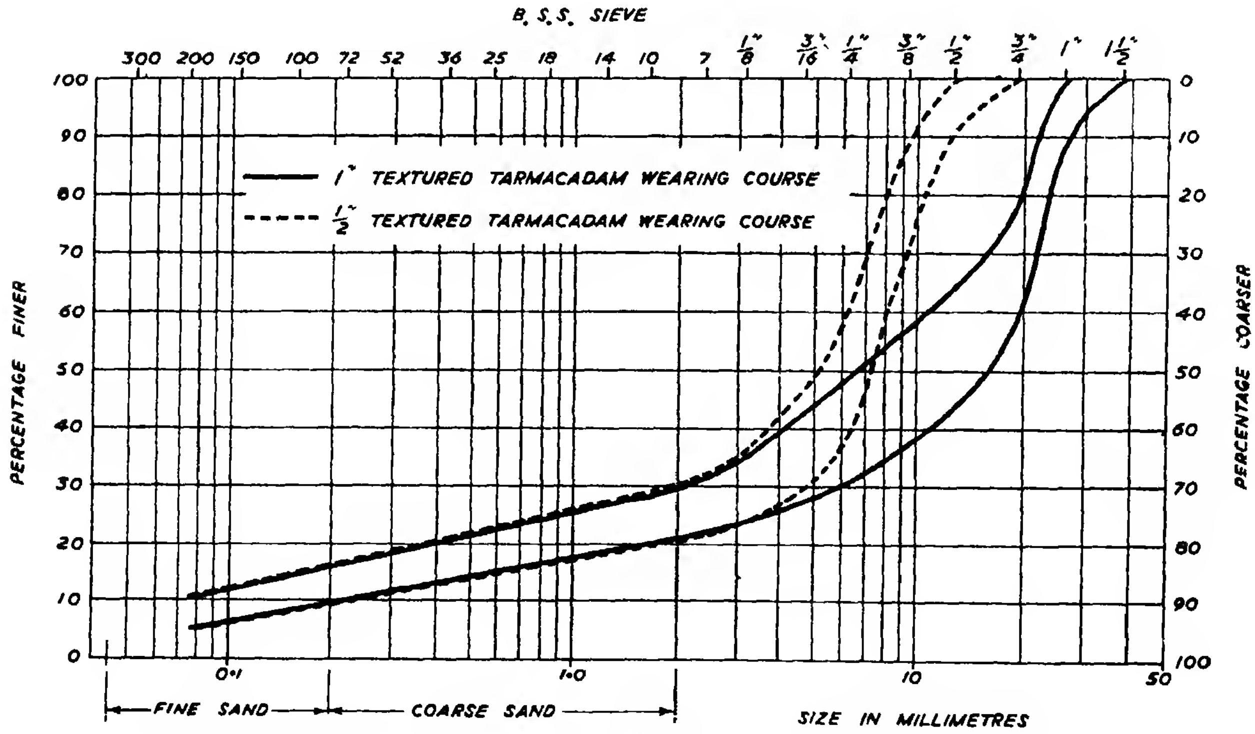


FIG 11g—B S. 802, TABLE IV, GRADING FOR CLOSE-TEXTURED WEARING COURSES, TO BE LAID HOT

Penetration Method

While satisfactory results have been obtained by using this method of construction, it is an inferior material to plant-mixed surfacing, since it is obvious that there cannot be the same meticulous control of grading, binder, etc as is obtained if plant-mixed material is used

(*For specification of method see B S* 433 · 1931)

Sand Carpets

During the war necessity has brought about considerable development of both wet and dry sand carpets using both tar and bitumen binders The term "sand carpet" has widely different meanings It may consist of selected materials such as crushed rock, gravel, blast furnace or steel slag graded ¼ in. to 200 mesh with pit sand added to obtain the specified grading Alternatively it may be made using naturally occurring sand on site with possibly other imported sand added to obtain the optimum grading This latter is considered by some engineers to be a form of soil stabilization, but as it is used as a wearing surface, on top of stabilized soil for example, it is here considered as a carpet

Generally sand carpets are only used where a plentiful supply of sand is available, but satisfactory coarse aggregate is not readily obtained Structurally these carpets have no other advantage over the usual types of carpets Very large areas have been laid all over the country and satisfactory results have been obtained where close control has been exercised If only light traffic is expected these carpets can be laid more thinly than is possible using coarser aggregates

The sand considered for the work should be submitted to laboratory test in order that the correct percentage of binder can be ascertained The binder used is a cut-back bitumen or Type A or B road tar E.V.T 27–31

If a hot plant-mixed material is used the carpet is similar to other asphalt surfaces, both for mixing, transporting and laying

If, however, sand obtained on site is used two methods of construction can be considered:

(1) Plant Mix —This can again be subdivided into stationary mixers and travelling plant.

This method has the advantage that the mixing is more even and also that there is greater control of the mix and finished thickness.

Stationary plant.—The disadvantage is that this method necessitates the transporting of the sand to the mixer and the mixed material back to the site. Where, however, the material is to be laid as a thin carpet this method must be used

Travelling mixers.—These machines pick up the sand, which has been formed into windrows ahead of the plant, feed it into the mixer, where the binder is added and the mix is delivered behind the machine to a travelling finisher Very large areas can be covered daily by this method which can be almost wholly mechanized

(2) Mix in-situ —This method consists of using normal soil stabilization methods The sand is harrowed, loosened, the binder sprayed on and thoroughly mixed by rotor tillers and finally compacted The minimum depth of finished work by this method is 3 to 4 in Work in excess of this depth should be constructed in two or more courses

Wet Sand Mix

The advantages of this method are that.

(i) A drying plant for the sand is not required
(ii) Inclement weather has a limited effect on the progress of the work

The essential difference between this method and the dry sand is that a "reagent" is added to the sand to assist the coating with binder The most commonly used reagent is hydrated lime which is added at the rate of 2 to 5 per cent by weight of sand Wetting agents are also required in the binder

Sand with a clay content in excess of 7 per cent by weight of the total will not usually be satisfactory for this work as it tends to remain "live" too long after placing

The finished sand carpet should be surface dressed when the surface appears "hungry" or is seen to be wearing

Disadvantages.—Unless hot mixed material is used the carpet remains live for a considerable time after laying and the surface will have to be re-rolled until the fluxes in the binder have evaporated

Advantages.—Very large areas of cheap dustless and impervious surfacing equal to a good quality tar or bituminous product can be obtained using local materials, by methods which are nearly independent of the weather Further, the low cost means that a good road surface can be obtained where the expense of other methods would normally necessitate the road being left unsurfaced or compel the use of less satisfactory materials On a good sub-base no base course is required

For more detailed information see contribution by Lee and Carter on "The Use of Cold and Wet

TABLES FOR SURFACE DRESSING

TABLE II

RATE OF SPREAD OF SURFACE DRESSING

Per 100-yard Length of Surface Dressing—at Sq. yards/Gallon

Width of Carriageway	3	4	5	6	7	8	9	10	11	12
9	100	75	60	50	43	38	33	30	27	25
12	133	100	80	67	57	50	45	40	36	33
15	167	125	100	83	71	63	56	50	45	42
18	200	150	120	100	86	75	67	60	55	50
21	233	175	140	117	100	88	78	70	64	58
24	267	200	160	133	114	100	89	80	73	62
27	300	225	180	150	128	113	100	90	82	75
30	333	250	200	167	143	125	111	100	91	83

TABLE III

RATE OF SPREAD OF CHIPPINGS

Rate of Spread in Sq. yards Ton; 100-yard Run

Width of Road	60	70	80	90	100	110	120	130	140	150
9	5·0	4·3	3·8	3·3	3·0	2·7	2·5	2·3	2·1	2·0
12	6·7	5·7	5·0	4·4	4·0	3·6	3·3	3·1	2·9	2·7
15	8·3	7·1	6·3	5·6	5·0	4·5	4·2	3·8	3·6	3·3
18	10·0	8·6	7·5	6·7	6·0	5·5	5·0	4·6	4·3	4·0
21	11·7	10·0	8·8	7·8	7·0	6·4	5·8	5·4	5·0	4·6
24	13·3	11·4	10·0	8·9	8·0	7·3	6·7	6·2	5·7	5·3
27	15·0	12·9	11·3	10·0	9·0	8·2	7·5	6·9	6·4	6·0
30	16·7	14·3	12·5	11·1	10·0	9·1	8·3	7·7	7·1	6·7

Aggregates in Bituminous Construction of Roads and Aerodromes"—Institution of Civil Engineers, 1944.

TAR-SPRAYING AND SURFACE DRESSING

Broadly speaking all surface dressing is done for one of the following reasons, (*a*) to provide a non-skid surface, (*b*) to preserve and seal the existing surfacing and render it impervious and (*c*) to provide a new wearing surface

Until recent years very little has been done to prepare a detailed specification for this class of work. This is probably due mainly to the fact that the unit cost of the work is low although the total annual expenditure for treating all the roads in a town or country division may be considerable Further, much of this work is undertaken by Local Authority Engineers whose maintenance gangs carry out the work directly Consequently the ordering of materials is under the direct control of the Local Authority and a detailed specification for applying the material has not been considered necessary.

Inferior workmanship and materials during the war led to the preparation of detailed specifications and the consequent improvement in the work which has resulted has been gratifying. In addition to these individual specifications, the Road Research Laboratory in conjunction with the Ministry of

War Transport prepared recommendations for tar surface dressings (*Wartime Road Note No 8, obtainable from His Majesty's Stationery Office*).

The specification is very comprehensive, covering the dressing of tar, bitumen, wood block, and concrete surfaces

In addition to the above mentioned Road Note copies of the following British Standard Specifications are relevant B S 76 1943 "Tar for Road Purposes", B S 63 1931 "Sizes of Road Stone and Chippings", and B S 812 1943, "Method for Sampling and Testing of Mineral Aggregates, Sands and Fillers"

In specifying tar it is only necessary to state the type of tar required and the Equi-viscous Temperature (E V T) and quote B S 76 1943 An engineer who has long association with roads can judge to within narrow limits the degree to which the surface to be treated is "hungry" and it is usual to specify a rate of application (for example 6 to 8 yds per gallon), but at the same time it is advantageous to obtain quotations in the tender for a higher and lower rate (i e in this instance 4 to 6 and 8 to 10) This will enable revisions to be made in the rate of application without the trouble of agreeing rates or obtaining revised quotations Experience indicates that the rate of application may vary more with the degree to which the existing surface is "hungry", than with the size of chippings, although for roads that are well maintained or on impervious surfaces this latter may be the ruling consideration.

Variations in the rate of application of the tar are frequently desirable from section to section of the road The quality of chippings used (e g. limestone, gravel, granite) also has a minor bearing on the quantity of tar required

Tables II and III give average rates of spread for surface dressings

Two points in the Road Note are of particular interest One is that best results can be obtained by the use of mechanical plant, e g Pressure tank sprayers—a more viscous fluid can be sprayed with a high pressure tanker than a low—and mechanical gritters. This ensures the even distribution of both materials over the road surface and greatest penetration of the dressing Whatever method of spraying is adopted it is important to ensure that the spraying nozzle is kept at a constant height above the road surface, and all spraying jets are thoroughly cleaned before work begins. Secondly the need for close control and sampling during the progress of the work is stressed. Fig. 12 illustrates tar-spraying in progress. A mechanical spraying machine for the application of cold emulsion is

FIG 12 —TAR-SPRAYING IN PROGRESS
(*Gas Light & Coke Co*)

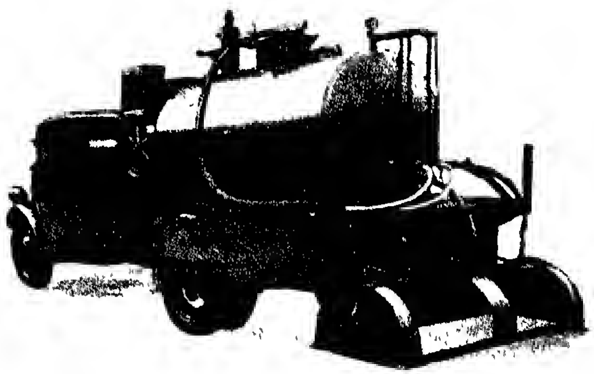


FIG. 13 MECHANICAL COLD EMULSION SPRAYING MACHINE
(*Phoenix Engineering Co Ltd*)

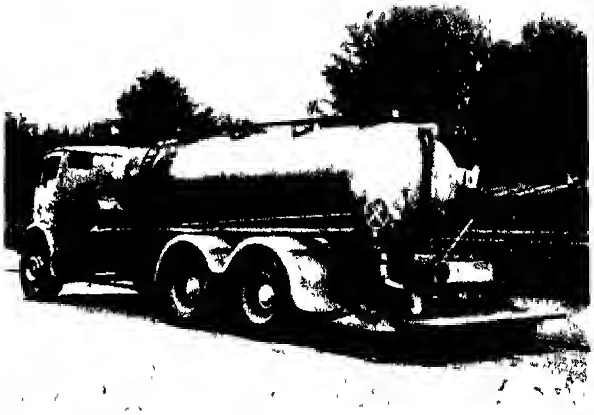


FIG 14 —MECHANICAL SURFACE DRESSING IN PROGRESS WITH TOWED GRITTER (5 CU YARD CAPACITY)
(*Gas Light & Coke Co*)

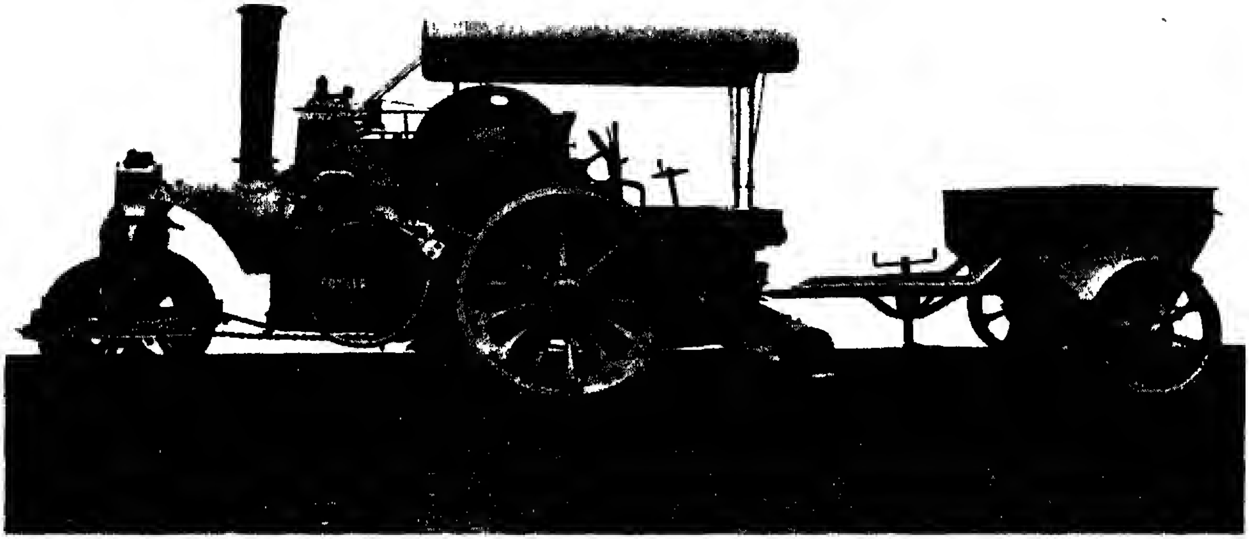


FIG. 15 — TAR-SPRAYING STEAM ROLLER WITH MECHANICAL GRITTER ATTACHED
(*John Fowler & Co (Leeds), Ltd*)

shown in Fig 13 Figs 14 and 15 show mechanical plant for surface dressing

Whilst it is obviously desirable that surface dressing should be carried out in the period April-September when the best weather conditions obtain, this is not always possible, and satisfactory results have been obtained during the winter months The work can be done using either tar or cut-back bitumen or cold bituminous emulsion If tar is used the temperature should be slightly higher and the viscosity rather lower than for summer use Cold emulsion has the advantage that dampness of the surface or the chippings is less important, on the other hand the results achieved using this material on roads subject to fairly heavy traffic are somewhat variable. For surface dressing wet roads, tests are now proceeding using tar in which a wetting agent has been incorporated.

At the present time, to obtain the best results a hot surface dressing is most desirable whenever it can be used Traffic should be kept off the finished surface for as long as possible or at least until the surface dressing has set and is holding the chippings. For hot dressings the surface should be dry at the time of spraying

If carelessly done, surface dressing will tend to accentuate existing irregularities. The application of hot tar causes slight softening of the tarmacadam below, and the chippings should therefore be spread immediately after the application of the tar and before the latter has cooled, otherwise the adhesion will be poor Immediate rolling following the gritting is essential Experience suggests that good work is difficult with wet chippings If they arrive on site thoroughly wet (e g straight from the washer at the gravel pit) it is desirable to allow time for them to drain before they are spread Some improvement is claimed by mixing the grading and quality of the chippings but if this is done the larger size should be spread first

If gravel aggregate is used particular attention is necessary to ensure that it has been thoroughly washed and is free from any deleterious matter The presence of even small quantities of clay or loam will detrimentally affect the adhesion of the tar to the gravel

Storage heaps of chippings at the sides of the road, if left for long periods, collect a lot of dust and dirt, which is a hindrance to good workmanship.

PREPARATION OF THE SURFACE

The cleaner the surface before work commences the better will be the quality of the finished job. Sweeping with a mechanical broom gives good results, but if the surface is particularly dirty the trouble of washing or hosing down will be amply repaid. Particular attention should be paid to the channels, where the majority of the dust and dirt of a modern road collects. Failure to take these precautions will almost certainly result in bare

patches appearing shortly after surface dressing has been completed. Wood block surfaces should be as dry as possible if good adhesion and penetration is to be obtained

Other Considerations

Loose Chippings.—If the work is being carried out by contract an item may be included for sweeping up surplus chippings from the finished surface on completion of the work These are only a nuisance to traffic using the road and after the binder has set no further adhesion between it and chippings will take place. The surplus chippings can usually be re-used elsewhere

Gullies, Manhole Covers, etc.—Care should be taken to protect gullies, manhole covers, hydrants, etc with a plate, or sand in some other approved manner, in such a way as to prevent the ingress of the binder into the seatings If some such precaution is not taken, considerable difficulty will be experienced when it is required to lift the covers after spraying has been completed It is important that all covers and gratings are left so that they can be easily moved on completion of the work

Channels—To ease the flow of water from the roadway to the gullies, a width of 9 to 12 in from the kerb is frequently left free from chippings, which are not really required on this area as it receives comparatively little wear The channel should, however, be sprayed or otherwise treated to ensure that it is impervious This comment does not apply to wood blocks, which should be sprayed and dressed to the full width

Emulsions

For small areas or where the use of a boiler is not warranted a bitumen or tar emulsion may be used as previously suggested There are many excellent proprietary emulsions Whilst these can be used in showery weather, their use in frosty weather is undesirable owing to the percentage of water

B S 434 1935 and B S 618 1935 give a full specification for bituminous dressings, and provided these are strictly adhered to and reasonable

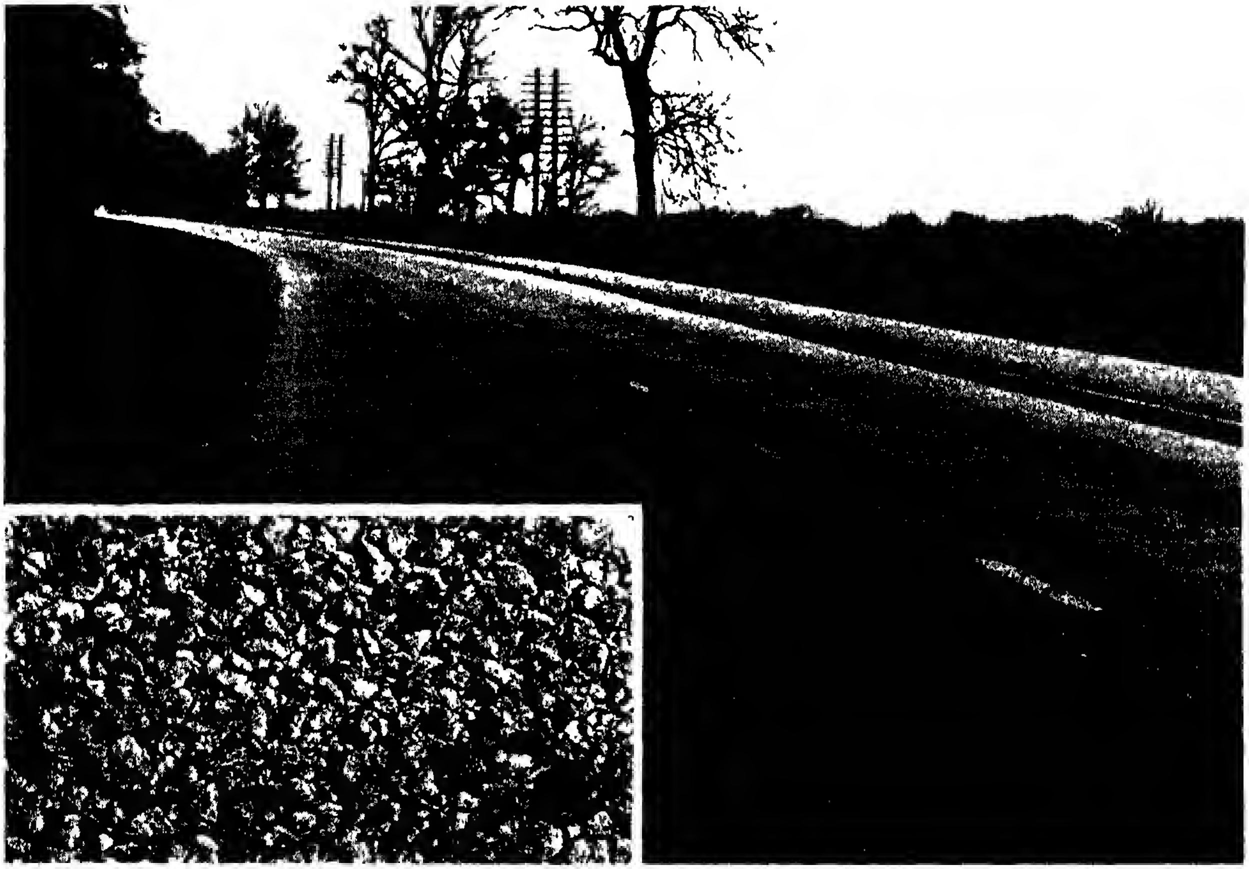


Fig. 16.—A Portion of the Great North Road, A 1, Surfacing Laid in 1937, Photograph taken in 1943. *Inset*—A Close-up of the Surfacing on Completion

(Gas Light & Coke Co)

care exercised in handling and storage there should be no trouble *

For emulsions a smaller size chipping should be used than for hot dressings. A higher rate of spread of emulsion is necessary owing to the percentage water content.

Solvents

In addition to ordinary emulsions there are bitumen solvent emulsions causing temporary softening of the surface and consequently better adhesion of the chippings It is claimed that solvent disappears readily and the chippings are rapidly held

Surface Dressing of Setts

Good results have been obtained on badly worn sett surfaces by giving frequent surface dressings Before the initial dressing, the joints of the old setts should be raked out as deeply as possible (about one inch), and then flushed up, using a tar-bitumen mixture. The surface of the road is then sprayed at 6 to 8 yds per gallon and given a heavy dressing of ½ in chippings The surface should be dressed again at the first sign of wear

Surface Dressing of Small Areas

For small areas a mechanically-operated pressure tanker is not warranted. Many methods are used, varying with the size of the area to be treated, ranging from watering can and spout spread with brush squeegee to 250 gallon boiler and spraying machine from which the material is pumped under pressure on to the road through a manually-operated spraying nozzle, the surface being gritted by hand Whatever method is used considerable skill is required For example, the rate of spread must be gauged by eye and care taken to keep the nozzle at a constant height The even spreading of grit also takes practice A skilled gang can satisfactorily surface dress about 3,000 yds per day, and make a better job of evening up irregularities in the existing surface. For large areas the relative costs of this method and mechanical spraying do not compare.

Non-toxic Sprays

Wherever roads drain directly into streams, non-toxic sprays should be used These may be enforced by the Ministry of Agriculture and Fisheries.

MAINTENANCE ORGANIZATION

It is generally the practice of Local Authorities to carry out maintenance work with their own staff. This varies from the smaller authorities who may employ a few men patching or surface dressing small areas, to the largest authorities who may have their own quarries and a considerable quantity of all types of plant

Quarries

While the site is chosen in order to obtain the best possible materials at lowest possible cost, it should also be situated at the most central position available in the area to be served in order to reduce transport costs This latter expense usually exceeds the cost of winning the stone

The quarry should be equipped with crushing and screening plant feeding direct into storage hoppers with a storage capacity according to production requirements, but usually not less than 20 tons To handle 300–400 tons of stone per day a labour force of approximately 60 men would be needed, half of this number being skilled men

Tarmacadam or Asphalt Plant

This plant is most conveniently situated at the quarry, thereby reducing the haulage on the greatest volume of material A further advantage is that a single supervisory staff can control all activities of quarrying and manufacture, and also test the finished product If a first-class product is to be achieved, vigorous control and testing at all stages of the work are essential, and centralization would justify the establishment of a small laboratory. The plant should be of such size as to supply normal needs for maintenance and for new work, both of which would require to be carefully planned to ensure that the plant is kept fully employed Additional supplies can be purchased as required from outside sources.

Portable manufacturing plant is seldom warranted in this country, and close control of the finished product is more difficult

Plant

It is not possible to suggest the amount of plant required, as this will vary with local needs. For any save the smallest Local Authorities it is an advantage to have a number of plant depots situated at strategic points within the division or area, with one central depot from which the heavier plant can be requisitioned. It is usually sufficient to have one, or perhaps two, fitters at each sub-depot who can handle normal routine maintenance of plant. The central depot should then be fully equipped with all necessary tools, machines and a good stock of spares The cost in establishing such a depot under the control of a qualified Plant Manager will be well repaid. History sheets of each vehicle

* See article on Road Emulsions, page 198.

FIG. 17 —FURNACE BOILER AND HAND SPRAYER AT WORK
(*Johnston Bros (Contractors), Ltd*)

or item of plant should be kept and routine inspections made from time to time. If the depot is well organized, the possibility of plant or vehicles breaking down while working on a job can be reduced to minor proportions

Generally the winter should be looked upon as the Plant Manager's busiest time and he should be satisfied in early spring that all his plant is ready and in the best possible order for the season's heavy programme

Smaller Local Authorities must depend on a fitter or two and the assistance of plant hire firms and the plant manufacturers, but again care in maintenance will avoid many an unnecessary and aggravating breakdown

Plant will include metal-lined lorries, light and heavy road rollers, tar-pots, gritters, pressure tankers, road sweepers, concrete mixers, spreaders, and finishers, pneumatic picks and road breakers, scarifiers, power shovels, etc

Materials

Normally the ordering of materials is done during the winter months In early autumn the following year's programme is planned and, later, materials are ordered for delivery to the points required. This work is normally the responsibility of the Divisional Surveyor and his staff Some materials, e g grit and emulsion, can be delivered to the point where they will ultimately be used, others must be taken into stock at the highway depot.

General Organization

In counties and in the larger towns the maintenance of roads in any particular area is the responsibility of the Divisional Surveyor for that area; in smaller localities the Highway Surveyor carries out the duties for the whole area He prepares estimates and, if necessary, obtains tenders for the work he considers necessary, such estimates being based on reports received from travelling foremen and lengthmen. The lengthman maintains his section of road to the best of his ability, cleaning grips, potholing, etc , but resurfacing and major repairs are undertaken by gangs under the supervision of the Divisional staff

Normally the Divisional Surveyor orders his materials, etc through the head office who then invite tenders for bulk supplies for the county or city The Surveyor is responsible for the checking of the quantity and quality of the materials supplied to his Division He is also responsible for the engagement, payment and discharge of all labour, and for certification of accounts

Unit Costing

Whilst there is considerable difference of opinion as to whether unit costing should be done in the Division (or at the quarry or plant) or at the head office, or yet again by the Council's Treasurer, there can be no doubt about the need for this work As the percentage of direct works increases so the need for accurate and up-to-date costing grows The key to the value of such figures is that they shall be up to date and for this reason local costing should be under the direct control of the official who is to use the figures obtained, namely the Engineer or Surveyor Figures for work carried out in the preceding year assist in the preparation of more accurate annual estimates for the succeeding year

Routine Maintenance

As far as possible all major maintenance and repair work will be left until the spring and summer months, but there is much work of a minor character that can be done during the less favourable season For minor roads this work can be handled by lengthmen who are responsible for a given length of road, but the work that they can do is obviously of a very limited nature. To supplement them and for general use on more heavily trafficked roads a mobile gang of, say, six men, equipped to carry out all but the most expensive repairs, is most useful.

THE CLEANSING OF ROADS

By H ARDERN, M.B.E., A.M I.Mech E., F. Inst P.C.

THE impressions formed by visitors to a town will most likely be based to a large degree on the cleanliness or otherwise of its streets. The clean condition of the building lines, gully grates, and the adequate provision of litter bins will also indicate, to the trained observer, the efficiency of the street cleansing service.

The type of street surface together with its condition, has a marked bearing on the effort required to keep it clean and this particularly applies when cleansing is carried out mechanically To obtain the best results it is therefore important that the surfaces shall be impervious and maintained in a thoroughly good condition

LAW RELATING TO THE CLEANSING OF STREETS, ETC

The legal aspect of street cleansing is quoted in some detail so as to collect under one heading a subject which is covered by several sections of various Acts of Parliament.

STREET CLEANSING AND WATERING

Sec 77 of the Public Health Act 1936, provides that:

"(1) A local authority may, and if required by the Minister shall, undertake the cleansing, and may undertake the watering, of streets as respects either the whole or any part of their district

"(2) Where a local authority have under this section undertaken the cleansing or watering of any streets with respect to which they are not the highway authority—

(*a*) the local authority may arrange with the highway authority for that authority to carry out the work on such terms as may be agreed;

(*b*) if the local authority carry out the work, the highway authority shall make towards the expenses of the local authority such reasonable contribution, regard being had to the extent to which the work is or was necessary for the maintenance of the street and the safety of traffic thereon, as may be agreed or, in case of dispute, may be determined by the Minister.

"(3) A local authority who have under this section resolved to undertake the cleansing of streets shall not, if their resolution was passed in compliance with a requirement of the Minister, rescind it without his consent "

Section 343 of this Act defines a street as any highway, including a highway over any bridge, and any road, lane, footway, square, court, alley or passage, whether a thoroughfare or not.

Section 86 of the Public Health (London) Act, 1936 states that

"(1) It shall be the duty of every sanitary authority to keep all streets in their district which are repairable by the inhabitants at large properly swept and cleansed, so far as is reasonably practicable and to collect and remove, so far as is reasonably practicable, all street refuse from such streets.

"(2) If any such street is not properly swept and cleansed or the street refuse is not collected and removed from any such street, in accordance with the requirements of this section, the sanitary authority shall be liable to a fine not exceeding twenty pounds.

"(3) The council of a borough may cause all or any of the streets in the borough to be watered as often as the council think proper.

"(4) If it appears to the county council that any street, being situate in more than one borough, ought for the purpose of cleansing or watering, to be under the exclusive management of one borough council, the county council may by order direct that the street shall for that purpose be under the exclusive management of that borough council."

Under section 304 of the same Act;

"Street" includes a highway, public bridge, any road, lane, footway, square, court, alley or passage, whether a thoroughfare or not, and notwithstanding the absence of houses.

"Street refuse" means dust, dirt, rubbish, mud, road scrapings, ice, snow or filth.

Section 78 of the Public Health Act 1936 states that

"(1) If any court, yard or passage which is used in common by the occupants of two or more buildings, but is not a highway repairable by the inhabitants at large, is not regularly swept and kept clean and free from rubbish or other accumulation to the satisfaction of the local authority, the authority may cause it to be swept and cleansed

"(2) The local authority may recover any expenses reasonably incurred by them under this section from the occupiers of the buildings which front or abut on the court or yard, or to which the passage affords access, in such proportions as may be determined by the authority, or, in case of dispute, by a court of summary jurisdiction "

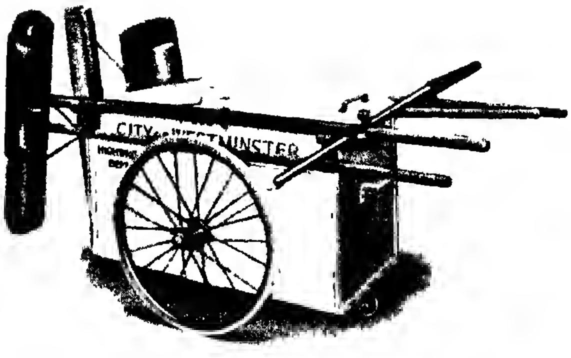


Fig. 1 -Street Orderly Truck

(Bristowes Machinery, Ltd)

Power to make Byelaws for the Prevention of Nuisances

Section 81 of the Public Health Act 1936 empowers a local authority to make byelaws for preventing the occurrence of nuisances from snow, filth, dust, ashes and rubbish.

Section 82 of this Act states that—

"(1) A local authority may make byelaws;

(a) prescribing the times for the removal, or carriage through the streets, of any fæcal or offensive, or noxious matter or liquid, whether that matter or liquid is in course of removal or carriage from within, or from without, or through, their district

(b) requiring that the receptacle or vehicle used for the removal or carriage of any such matter or liquid shall be properly constructed and covered so as to prevent the escape of any such matter or liquid·

(c) requiring the cleansing of any place whereon any such matter or liquid has been dropped or spilt in the course of removal or carriage.

"(2) If and so far as a byelaw made under the preceding subsection is inconsistent with a regulation made under section ten of the London Traffic Act 1924, the regulation shall prevail "

Section 84 of the Public Health (London) Act 1936 requires that.

"(1) Every sanitary authority shall make byelaws

(a) for the prevention of nuisances arising from snow, ice, salt, dust, ashes, rubbish, offal, carrion, fish or filth, or other matter or thing in any street

"(2) Under this section, the county council shall make byelaws·

(a) for prescribing the times for the removal or carriage by road or water of any fæcal or offensive or noxious matter in or through the county, and providing that the carriage or vessel used therefor shall be properly constructed and covered so as to prevent the escape of any such matter and so as to prevent any nuisance arising therefrom.

"(3) It shall be the duty of every sanitary authority to enforce the byelaws made under this section

"(4) Except as otherwise provided by byelaws under this section, a constable may arrest without warrant, and take before a justice, any person whom he finds committing an offence under such byelaws and who refuses to give his name and address

"(5) Byelaws under this section shall not make it an offence to lay sand or other material in any street in time of frost to prevent accidents, or litter or other matter to prevent the freezing of water in pipes or, in case of sickness, to prevent noise, if the same is laid and, when the occasion ceases, duly removed, in accordance with the byelaws "

Street Orderly Bins

Section 76 of the Public Health Act, 1936 empowers a local authority to provide receptacles for refuse in streets and public places.

FIG. 2. KARRIER "BANTAM" STREET SWEEPER

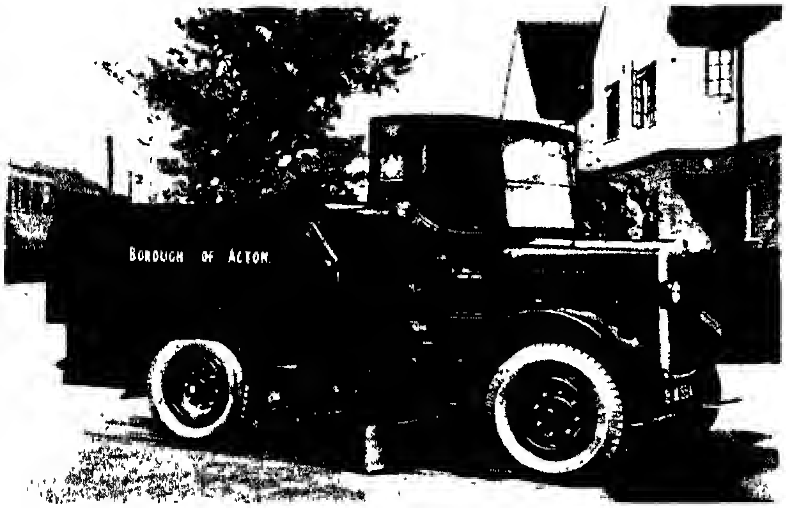


FIG. 3—KARRIER "R.S.C." ROAD SWEEPER AND COLLECTOR

Section 13 of the Public Health Act 1925, which is an adoptive Act, gives power to provide orderly bins for the storage of sand, grit or shingle. Powers in this connection are also provided under private Acts.

Section 33 of the London County Council (General Powers) Act 1928 states that:

"(1) A borough council may provide and maintain in upon or under any street vested in or repairable by them orderly bins or other receptacles for the collection and temporary deposit of street refuse and waste paper and the storage of sand, grit, shingle or cinders of such dimensions and in such positions as the borough council after consultation with the Commissioner of Police of the Metropolis may from time to time determine.

"(2) Nothing in this section shall empower a borough council to hinder the reasonable use of a street by the public or any person entitled to use the same and a borough council shall not exercise their powers under this section in such a way as to create a nuisance to any adjacent owner or occupier."

EMPLOYEES—UNIFORM AND TRAINING

The selection and training of employees is of very great importance, firstly, because upon these depends the efficiency and economy of the service, secondly, because the Council will be judged largely by the type of men which it employs and the manner in which they carry out their duties.

Smart, serviceable uniform should be provided, particular regard being paid to protective equipment to enable the men to carry out their duties in all kinds of weather.

Present-day street orderlies are required to be conscientious, intelligent, active and of clean and smart appearance. For the first day a new man should be accompanied by an experienced employee whose duty would be to show him over his section, explain the duties and satisfy himself that they are fully understood. Older men and men not physically fit should be employed on the quieter sections where they will not be subject to risk from traffic. It is a good plan to change the street orderlies from one section to another from time to time.

LITTER

The practice of street littering is widespread and the procedure for enforcing the byelaws cumbersome, so that many officers in charge of the

cleansing services would welcome more direct action against offenders on the lines adopted by some continental countries

The provision of an adequate supply of litter receptacles placed at the most suitable positions, is sound policy The types in use are varied and there can be little doubt that there is room for considerable improvement in their design

The use of these receptacles for the display of advertisements other than those relating to the Council's own activities is not recommended.

Fouling by Dogs

The fouling of pavements by dogs is very objectionable and some owners appear to pay little attention to the amenities of other pedestrians, a number of whom send letters of complaint to the council

Where a byelaw is in force making it an offence for a person having charge of a dog on a lead to allow it to foul the footway, it should be enforced and the co-operation of the police invited in order to procure prosecutions against the offenders Warning notices, quoting the section of the byelaw should also be displayed, particularly in those neighbourhoods where excessive fouling takes place

SWEEPING

The sweeping of streets may be done by manual or mechanical methods

Manual Sweeping

In busily-trafficked streets, manual sweeping on the beat system is generally practised In special circumstances, e g when the leaves are falling, the work may in some cases be carried out more expeditiously, however, if the men are set to work in gangs, sweeping and heaping the leaves in readiness for collection by a vehicle. With the beat system each man is allotted a section, the area of which is chiefly determined by the importance of the streets and the amount of fouling which takes place. The orderly is provided with a truck (see Fig 1) which carries two, and sometimes three, bins into which he puts the street refuse. Equipment includes a hair broom and squeegee for the pavements, a bass broom for the roadway and channels and a shovel The bass broom is generally fitted with a scraper

Sweepings are either deposited in pits sunk in the pavement from which the material is collected later by vehicle, or the contents of the orderly truck bins are emptied direct into a vehicle which meets the orderlies at pre-arranged positions and times A feature which has been successfully introduced by some local authorities is to embody a small orderly truck store as part of the structure of new public conveniences in suburban districts.

For suitable districts, tricycle orderly trucks can be used to great advantage but should be restricted for the use of young and agile employees The employment of this type of truck may very well show a considerable financial saving especially where it is practicable, as a result, to reduce the number of depots

It is generally found that market streets are

Fig 4.—Street Washing Trailer Coupled to a Scammell 3-ton Mechanical Horse

(*Scammell Lorries, Ltd*)

difficult to maintain in a clean condition owing to the nature of the refuse produced and the volume of traffic.

To lessen the throwing down of refuse onto the street, some local authorities insist on the stallholders providing dustbins for the reception of such material. A disadvantage of this system is that the stallholder may be placed in some difficulty should he wish to leave earlier than the usual closing time and still have a quantity of refuse to be removed. It is possible, therefore, that if a local authority operates the refuse storage container system the provision of one or more of these receptacles in market streets may overcome difficulties previously encountered.

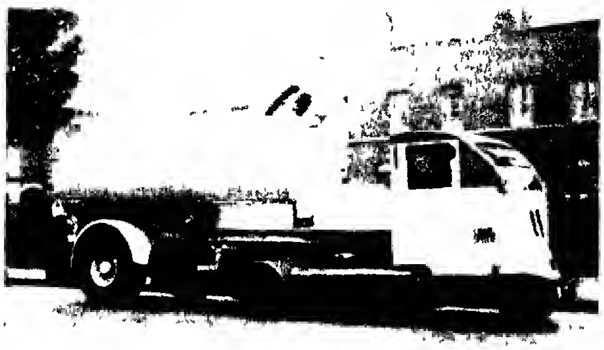


FIG. 5.—ELECTRICALLY-OPERATED GULLY EMPTIER. Motive unit: Electrical Scammell; Gully-emptying equipment by Dennis Bros.

MECHANICAL SWEEPING

Various makes of mechanical sweepers and sweeper-collectors are used in most of the larger towns and it is hoped that in the near future the range of these machines will be extended and their usefulness further enhanced. Fig. 2 shows a mechanical sweeper, and one type of sweeper-collector is illustrated in Fig. 3. With the former type it is important that collecting vehicles should follow immediately, so that the sweepings are not scattered by the wind or by other traffic. With both types of machine it is usual for a man to sweep the pavements just in advance of the vehicle. If the best results are to be obtained by mechanical sweeping, it is essential for the routes to be so planned and timed that there is the minimum of obstruction from vehicles parked at the kerbside. Night or early morning is therefore usually the best time for employing machines, but the choice of time depends chiefly upon the district in which they are employed.

WASHING AND SPRINKLING

Opinion is divided as to the relative merits of manual flushing by hose fitted to standpipes and mechanical flushing by tank vehicles, such as that illustrated in Fig. 4.

With the former, a greater quantity of water is used and the operation is slower, but it has the advantage that where patches of the roadway are badly fouled they can be dealt with more effectively. Hand flushing can also be carried out in courts and alleys which are inaccessible for vehicles, although some street washing vehicles are equipped with a reel of small diameter hose which can be used for this purpose.

For the effective washing of street surfaces, duck-foot jets are provided, through which the water is delivered under pressure. The control of the power-operated pump unit may provide a pressure from 30 to 80 lb. per sq. in.

A useful adjunct to the street-washing vehicle is a rotary broom or squeegee.

In hot weather, sprinkling of the roads during the day-time lays any dust and makes conditions more pleasant for the public. The maximum width of spread under pressure for mechanical vehicles is about 90 feet.

GRITTING AND SANDING

Unfortunately from a cleansing viewpoint, the application of grit or sand to many roads is still necessary to counteract slipperiness in wet or frosty weather.

The throwing down of grit, etc., is wasteful of material and labour and in any case is only a palliative as it is quickly wafted to the channels and centre of the road by fast-moving traffic. Much of the grit also finds its way to the street gullies. Where road surfaces have been treated with non-skid material the saving effected by abolishing the need for gritting has been considerable, the streets have been tidier, freer of dust and the risk of accidents greatly reduced. Gritting is done by hand-spreading and by machine. With the former there is likely to be more waste of grit and the spread will be less even. Employees should be warned that when spreading grit, care must be taken to avoid the possibility of injury to pedestrians or damage to the paintwork of vehicles, etc. To ensure easier and safer distribution, small hand shovels have been issued by some local authorities.

The selection of grit, free from sharp flint, is essential to prevent damage to tyres. The spreading of sand mechanically is not very successful

as if at all damp the material has a tendency to clog on the distribution plate

GULLY EMPTYING

Mechanical gully emptying is now practised by most local authorities—electric, petrol and a small number of steam vehicles being used

The improvement in the design and operation of the petrol vehicle has resulted in its greater popularity and it is likely that this type will continue to be widely used

The electric gully emptier (see Fig 5) is particularly suitable for night work owing to its silent operation The proportion of the total tank capacity allotted for clean water and sludge is determined by local factors and the design of the gully-emptying machine A good design of gully emptier should ensure that the greatest quantity of fouled water is released from the sludge tank whilst at work in order to accommodate the maximum amount of solids and to facilitate and assist in the disposal of the detritus

SNOW CLEARING

By July, salt stocks should be built up to the required level By September, it is a good plan to set out and if necessary amend the organization which will be required to cope with snowfalls This should show

(*a*) Emergency calling out arrangements
(*b*) Districts, with names of supervisors and foremen in charge
(*c*) Classification of streets in order of priority
(*d*) Disposal positions for snow, i e, location of sewer manholes, etc

There appears to be room for improvement in the existing methods for the mixing of salt with grit or sand

Manual mixing by hand shovels at the time when it is required is not very satisfactory and perhaps a better method would be to arrange for mechanical mixing and storage of the mixture beforehand, in readiness for use.

When salt has been stored for some considerable time it tends to become very hard. When it is eventually required it is wanted in a hurry and the usual procedure is to break it up with picks, etc The addition of a little water, just sufficient to damp the crust, is helpful, but care should be taken that only the quantity of salt required for immediate use is so treated

If it is considered likely that snow may fall during the night or week-ends when few of the staff are available, it is as well to be prepared by having one or two vehicles already loaded with salt and grit so that, if necessary, the material can be despatched and spread with the least possible delay

A memorandum issued by the Cement and Concrete Association deals with the effect of salt on concrete surfaces and an extract is given below

"In the exceptionally severe winter of 1935-36 damage was caused to many roads, especially in the Northern districts, by the application of salt for the purpose of removing snow and ice As many of these roads had been similarly treated in previous years and had suffered no harm thereby, investigations were commenced at once in order to discover the cause of the trouble and to ascertain how it could be prevented in the future

"The conclusions drawn from these investigations, which closely resembled the results of similar research work carried out in America, are summarized here

"In general, it may at once be stated that the

FIG 6—SNOWPLOUGHS AT WORK IN LONDON
Photo shows a snowplough clearing the road at Victoria during a cold spell
(*Topical Press*)

FIG. 7. THIS PHOTOGRAPH SHOWS BAKER STREET, LONDON, DURING ONE PERIOD OF THE ARCTIC SPELL IN MARCH, 1947. THE CONDITIONS WERE CAUSED BY THE PASSAGE OF HEAVY TRAFFIC OVER SUCCESSIVE LAYERS OF SNOW WHICH FROZE SOLID

(By courtesy of "The Evening Standard")

occasional application of salt properly mixed with sand or similar gritty material will have no deleterious effect on a concrete surface. The damage that occurred was due to physical causes and not to any chemical reaction of the salt.

"The damage to road surfaces already saturated with moisture has been traced to the too-frequent application of salt, coupled with alternate thawing and freezing. The effect was that a concentrated salt solution formed and the temperature was lowered to such an extent that the moisture on the road surface froze, thus causing a disintegration of the concrete. It will be realized that only abnormal conditions produced this result.

"If a salt (sodium chloride or calcium chloride) is used it should be in granular form and mixed with about four times its volume of sand or other gritty material and spread uniformly over the frozen area. One or two such applications distributed by means of a mechanical spreader will have the desired effect without causing damage to the concrete, but further applications may result in the formation of a concentrated solution.

"The practice of shovelling or scattering the salt directly onto the surface without the addition of sand or cinders should never be adopted, for it almost invariably leads to the formation of concentrated solutions of the chloride when thawing takes place, thereby creating a grave risk of injury to the concrete."

With a light or moderate fall of snow it will generally be found advantageous to use a mixture of sand and salt or grit in the proportion by volume of four parts sand or grit to one part of salt, but this proportion may sometimes need to be varied. The main streets should be treated with the mixture as soon as it becomes obvious that the snow will not be dispersed by natural means. The atmospheric temperature has to be watched very closely as a few degrees variation may make all the difference between a large or small expenditure.

With a medium or heavy fall of snow, such as that illustrated in Fig 6, and a low temperature, snow ploughs may be needed for the carriageways whilst the clearance from footpaths should be undertaken by sweepers with shovels or flanders, particular attention being given to bus stops and pedestrian crossings A little salt and grit may be used on the path cleared by the ploughs Small petrol-driven ploughs can be employed very successfully when the snow is soft or slushy but they are of little use if it has become consolidated

The snow from the footpaths and carriageways should be formed into ridges in the channel with spaces provided for pedestrians These ridges can be left for the time being, except possibly in the busier streets, provided that the gutters and gullies are kept free to allow for drainage The heaping and cartage of snow to the sewers or other dispersal points is a slow and costly business and should be resorted to only when other means of dispersal have been unavailing If the atmospheric temperature rises sufficiently to cause the snow to melt, ploughs can be used very successfully by making several cuts into the ridge left in the channel, and forming the snow into three or four ridges directly in the path of the traffic which will soon break it up The salt and grit placed on the carriageway when the snowploughs were first used, will assist in this process and spreading of the ridges over the main traffic run by sweepers with hand shovels will generally ensure rapid dispersal.

Selected employees should be placed in charge of gangs of casual labourers, their duties being to check on the issue and return of tools, and to see that there is no slacking A careful record should be kept showing the time of commencement and cessation of the fall, depth, temperatures, quantity of salt used, number of casuals and hired vehicles engaged, complaints received, etc

The exceptionaly severe weather conditions during the first three months of 1947, combined with the serious shortage of manpower, have emphasized the urgent need for improved mechanical means of snow clearing in this country

The consequences which may arise from the lack of such means are illustrated in Fig 7

MANUFACTURERS' DATA ON MAINTENANCE EQUIPMENT AND MATERIALS

ALEXANDER ASPHALT CO, LTD, BRISTOL, 9

Roads reconstructed or resurfaced with most up-to-date plant Portable Mixing plants and Mechanical Spreaders available Complete thoroughfares constructed including drainage Manufacturers of "SOLUTIAS" and "SOLUTAR" bitumen and tar emulsions

W & F ARCHER, LTD., LONDON, N 18

"TARGET" Brand Scavenger brooms made of pure Bahia Bass mixture or of African bass 13 in 16 × 5 knots, also Patent Scavenger Brooms, 15 in Flatstock 17 × 4 knots, with a special reversible socket for holding stale.

All types of bass Mechanical Sweeping Machine broom stocks for Lewin, Karrier, Lacre and Horse brooms Tarring brooms, in three sizes –9, 14 and 21 in Brooms and brushes of all descriptions to meet the requirements of road workers

THE ASSOCIATED EQUIPMENT CO, LTD, SOUTHALL, MIDDLESEX

THE "IDEAL" REFUSE COLLECTOR mounted on A.E.C "MONARCH" chassis provides a loading capacity of 15 cu yds It has a drum-shaped, two-compartment body divided by a baffle plate The main and larger compartment constitutes the container proper, while the smaller one is really a collecting chamber, or hopper, which is loaded from road level The rear-loading hopper is filled with refuse and the body is rotated upwards to an angle of 123° This position brings the rear hopper over the body centre and causes the load therein to fall some 9 ft at the first tip and thence by reducing distances, until completely filled Thus packing is effected by falling and pounding During loading operations previous discharges roll inside the body and consolidate For the accommodation of bulky and unwieldy rubbish a compartment is provided immediately behind the driver's cab (Plate II, Figs 1*a*, *b*, *c*, *d*)

Tower wagons mounted on AEC "MONARCH" chassis are constructed by the Eagle Engineering Co, Ltd The height of the tower is adjustable so that work can be easily carried out on overhead equipment When fully raised, a 3-section tower reaches a height of 30 ft, a 4-section tower 35 ft (See also "Manufacturers' Data on Road-Making Equipment" page 333)

JOHN BLACKWOOD & TINTO, LTD, GLASGOW, E 1

This firm is mainly engaged in the overhaul of contractors' heavy plant, and is equipped for the manufacture of any necessary components which may be in short supply Specialists in the complete overhaul of track-laying tractors Quick service in re-pinning and re-bushing of tracks is available

BRISTOWES MACHINERY, LTD., LONDON, N 18

THE GRIT AND SALT SPREADER (Plate I, No 2), for distributing grit to prevent skidding on greasy or icy roads, can treat a 30-ft road in one operation Salt can be spread on footpaths as well as roads in the same operation, the attachment can be fitted to any lorry

Other maintenance equipment includes the barrel trolley and patching outfit complete with tar-pan, heating tray for chippings and fire-box to lower for drying potholes, 3 or 4 wheel type patching or dipping pan in 8, 10 or 12 gallon sizes; sundry small tools for asphalt, etc

There is a range of equipment for the cleansing of roads, which includes the sanitary street refuse and sanding truck, the "COUNTY" general purpose truck; the "CITY OF ORDERLY" refuse collecting and sanding truck mounted on pneumatic-tyred ball-bearing wheels is fitted with rubber grip handles, a coat locker is provided (Plate II, No 4), several other types of refuse collecting and sanding trucks are also available (See also "Manufacturers' Data on Road-Making Equipment, page 335)

THE BUELL COMBUSTION CO, LTD, LONDON, S W 1

Dust Collectors for dedusting gases from stone dryers and air from screens, etc, with special cyclones having high separator efficiency and occupying comparatively small space All sizes are available and various types are manufactured to customers' requirements

WILLIAM BUNCE & SON, ASHBURY, SWINDON

The "ASHBURY" road gritting machine for the treatment of icebound or slippery road surfaces The machine is coupled to a lorry and the grit is drawn down the V-shaped trough and through the distributing apertures at the base by means of revolving lugs attached to the wheel axle, and by the same means the grit, sand or salt is disintegrated if wet or frozen The apertures are adjustable Size 1 has a distributing width approximately 6 ft 6 in There is also an ASHBURY gritting machine for following tar-spraying

The Bunce range of snow-ploughs are either one-way type, 22 and 33 in deep, or the V-type, 4 ft and 2 ft 6 in deep The lorry plough (Plate 1, No 11) a one-way type, is suitable for attaching to most makes of vehicles The standard size is suitable for 30 cwt to 3-ton vehicles, and the heavier size for 3-tonners and over

The heavy duty VEE snow plough has a cutting width of 7 ft 6 in to 8 ft The depth of plough is 4 ft and is suitable for dealing with deep snow and snow drifts This plough is made of special steel and includes suitable under-frame for attachment to road vehicles (Plate 1, No 10)

Other equipment includes motor footpath snow plough, motor footpath gritter, motor footpath snow plough and gritter combined, horse-drawn footpath snow plough, and squeegees (Plate 1, No 8), the latter having rubber fitted in place of tipping blades on the one-way type snow plough

CARRIMORE SIX WHEELERS, LTD, LONDON, N 12

All steel refuse bodies with sliding covers, dust-proof and low-loading, 7 to 12 cu yds capacities, for house refuse collection (See also "Manufacturers' Data on Road-Making Equipment", page 337)

THOMAS COLEMAN & SONS, LTD, DERBY

The "SPINNER" gritter with rear spread for gritting of road surfaces during frosty weather to prevent skidding, etc

NORMAN W. DUNN & CO, LTD, DUNNINGTON, YORK

Burning-off work carried out by contract Fatty and corrugated surfaces burned off and trued-up, and camber of road reduced Work executed with Laidlaw-Drew burning-off machines (See also "Schedule of Road-Making Materials", page 217)

W. & J GLOSSOP, LTD., OSBALDWICK, YORK

Pioneers in road-making and specialists in surface dressing work and producers of self-propelled spraying tankers The latest machines combine self-heating, spraying and mechanical gritting, Plate I, No. 9.

GLOVER, WEBB & LIVERSIDGE, LTD., LONDON, S.E.1

THE "TRANSPORT" PATENT MOVING FLOOR REAR LOADING REFUSE COLLECTOR (Plate II, Nos 2a, b, c, d), available on a variety of chassis, has been developed over a number of years to suit the needs of collection in both town and country areas.

The post-war model while incorporating all the main features of the well-tried pre-war design has many improvements in detail These include the alternative fitment of a galvanized floor of a new type, having greater strength and improved resistance to corrosion or an acid resisting rubber belt floor a new compensated sliding loader's platform simplified maintenance, with single shot high pressure lubrication to the rear shaft and other vital parts greater accessibility and ease of adjustment

The machine provides for rapid rear loading, one easy step from the roadway, avoids the unsightliness and dust nuisance of side loading, and by use of the moving floor enables the loaders to pack the body, utilizing the full carrying capacity of the chassis with consequent saving of both capital and collection costs The tailboard rises to the top of the body giving a completely free exit for the refuse when the body is emptied by use of the floor A two-speed reduction gear makes the work of discharging an easy one Power operation can also be supplied, incorporating a patent clutch with which it is impossible to tamper This clutch permits a definite amount of compression of the load without risk of injury to the mechanism Power-operated floors will discharge the load in 25/30 seconds The design provides ample ground clearance for discharge on uneven ground

WILLIAM GOODACRE & SONS, LTD, LONDON, E 16

Specialists in the maintenance and repair of all makes and types of Grabs, also the reconditioning and replacement of all classes of lifting gear

JOHNSTON BROS (CONTRACTORS), LTD, LONDON, E C 3

THE "QUICHEAT" ROAD HEATER (see Fig 9, page 403) is a compact and portable unit arranged for hand manipulation with drawbar or horse shafts for transfer from one working point to another, and is used for drying, heating, softening or burning off road surfaces which require reconditioning

THE "ROADMENDER" is a quick acting repair outfit comprising a stone and sand dryer, a bitumen heater and a paddle-type mixer This machine saves the use of a large plant on small repairs and often enables local aggregates to be used, thus saving carriage costs The capacity ranges from about 4 cu yds with the small unit up to 16 cu yds per day with the larger machine

THE JOHNSTON "BACK GRITTER" can be hauled behind any lorry and has a threefold utility, it can re-spread existing grit, add a portion of new, or spread entirely new grit The speed of working is from 8 to 15 m p h

THE JOHNSTON "LEAF LIFTER" is a pneumatic and mechanical means of lifting leaves and light litter from roads and parklands rapidly and thoroughly The lifting is done by flexible suction pipes which work from side to side of the chassis followed by a revolving brush, circular in cross section Single or twin type machines are available, and the suction pipes in each case can be used inside or outside the chassis width (Plate I, No 5)

THE JOHNSTON "FLYER" GRITTER for rapidly gritting roads which are slippery in winter due to frost, in summer due to "bleeding" of tar or bitumen It can easily be attached behind any lorry and controls gritting width of from 3 to 30 ft With a working speed of 8 to 15 m p h, it works on the near side of the road but puts the grit on the crown of the road. Single and twin types are available (Plate II, No 6)

THE JOHNSTON "PAVEMENT" CLEANER for the rapid removal of fine dust and litter from pavements and floor areas The machine operates by a combination of suction cleansing and sweeping, effective over the whole width of the machine The combination is achieved by a specially-constructed and arranged suction pump and a flexibly-mounted rotary brush The whole equipment is mounted on a steel-framed chassis having standard motor car type controls The driver is at the rear end where he can watch all work done (Plate II, No 7)

THE JOHNSTON MIDGET DRYER is used for drying road channels, roads prior to white line painting, and pot holes before repairing, etc The machine is mounted on three steel wheels, and is oil fired

THE HAND-PROPELLED WHEELBARROW TYPE MECHANICAL GRITTER meets the demand for a small unit which can be brought into immediate service by a roadman unaided The quantity of spread per square yard is adjustable and the width of the spread is up to 20 ft and the length covered for each filling is 100 to 150 yds

SMART'S MIDGET PATCHING OUTFIT is suitable for repairs to woodpaving, footpaths and roads, etc

THE "JOHNSTON" MOBILE SWEEPER AND COLLECTOR has facilities for sweeping in the channels by means of an auxiliary channel brush which is flexibly mounted on the near side just forward of the front wheels The sweeping and collecting equipment consists of a main brush, conveyor, refuse bin and channel brush, and the machine is equipped with a sprinkling device which is controlled by the driver The weight and size of the machine enables it to be used on footpaths and other narrow ways (Plate II, No 3)

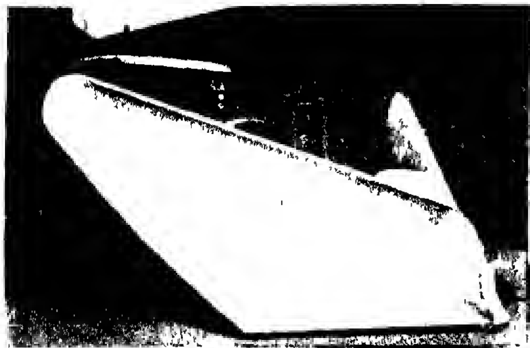
There are various types of "JOHNSTON" SNOW PLOUGHS including the MULTIPLE PURPOSE STREET ORDERLY which is a self-propelling type, so arranged that the main chassis and the power unit are available for a variety of different purposes other than snow clearing, the "URBAN" type, which is specifically intended for use in built-up areas and for attachment to vehicles ranging from 30 to 50 cwt, THE STANDARD STRAIGHT BLADE PLOUGH, capable of dealing with snow up to 2 or 3 ft in depth and with drifts of even greater depths The blade is straight, inclined at an angle of 30° so as to deliver snow to one side of the road, the STANDARD VEE BLADE PLOUGH which delivers snow in equal amounts to either side of the vehicle as it proceeds This is used where heavy work has to be undertaken and should not be attached to anything lighter than a 4-ton vehicle, and the "HIGH WING" VEE BLADE PLOUGH which is similar to the Standard Vee Blade but the Vee Blade is lower at the nose and brought up to a high elevation at the outer wings or extremities This facilitates high speed ploughing in country areas (Plate I, No 1)

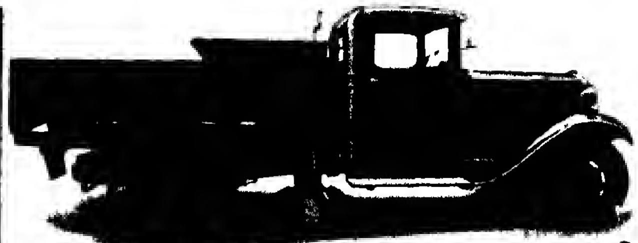
For rectifying the irregularities in existing road surfaces and eliminating impact the "JOHNSTON MECHANICAL NIMPACTOR" is a chassis mounted on pneumatic-shod wheels which accommodates a specially arranged underslung chassis on which an arrangement of cutting blades is provided together with the necessary motive power by means of the cutting blades this machine removes surplus material from a road surface (See also "Manufacturers' Data on Road-Making Equipment", page 341)

KARRIER MOTORS, LTD, LUTON

THE "KARRIER-YORKSHIRE" GULLY EMPTIER specially designed for the "CK3" chassis, has several new technical developments to meet post war demands While the capacity, 750 gallons, remains the same, the all-welded tank is now divided into four compartments for compressed sludge, surplus water, re-sealing water and cooling water, and incorporates a new method of sludge disposal known as "piston discharge" Other improvements include a redesigned gear-driven vacuum pump of the water seal type with a phosphor-bronze rotor running in an aluminium-alloy casing, which is provided with inner surfaces of hard chrome plate to prevent corrosion while standing (Plate I, No 4)

THE KARRIER "BANTAM" TWO-TONNER already noted on page 422 can be equipped with a refuse collecting body (See also "Manufacturers' Data on Road-Making Equipment", page 343.)





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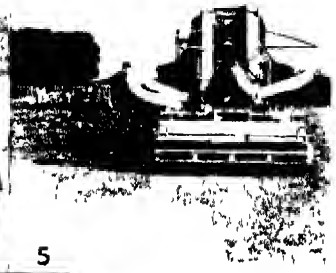

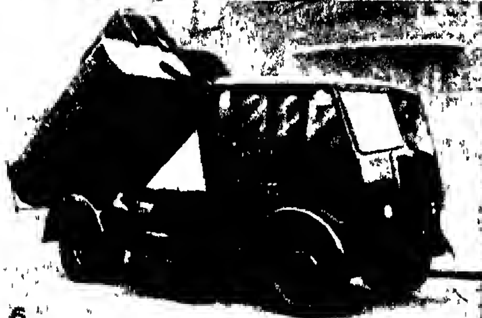

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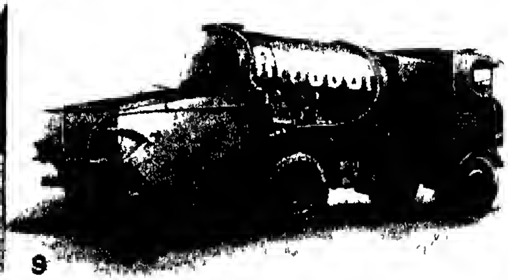

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PLATE I

1 and 5. Johnston Bros.' "HighWing" Vee Blade Snow Plough and Johnston Leaf Lifter.

2.—Bristowe's Machinery Grit and Salt Spreader.

3 and 6. Lewin Road Sweeper Mounted on Thornycroft "Nippy" Chassis, No. 3 shows the three-quarter rear view and No. 6 the body tipped for discharge of refuse.

4. "Karrier-Yorkshire" 750-Gallon Gully Emptier.

7. Lewin Compressing Refuse Collector, mounted on Vulcan Chassis.

9.—Glossop Self-propelled Heating, Spraying and Gritting Tanker.

8, 10 and 11. William Bunce's Squeegee, Heavy Duty "V"-shaped Snow Plough, and Snow Plough with Blade ready for use.

PLATE II

1.—ASSOCIATED EQUIPMENT CO.'S "IDEAL" REFUSE COLLECTOR. 1*b* SHOWS THE LOADING POSITION, 1*c* THE TIPPING OR LOAD-PACKING POSITION, AND 1*d* THE DISCHARGING POSITION.
2.—GLOVER, WEBB AND LIVERSIDGE'S "TRANSPORT" ALL-STEEL REAR-LOADING, MOVING-FLOOR REFUSE COLLECTOR. 2*b* SHOWS THE LOADING POSITION, 2*c* THE BACK CLOSED FOR TRAVELLING TO TIP, AND 2*d* THE BACK OPENED FOR DISCHARGE OF REFUSE.
3, 6 AND 7.—JOHNSTON BROS.' MOBILE SWEEPER-COLLECTOR, SINGLE FLYING GRITTER AND PAVEMENT CLEANSER.
4.—BRISTOWE'S "CITY OF ORDERLY" TRUCK.

LAIDLAW DREW & CO, LTD, EDINBURGH, 6

Oil fired road heaters or burning-off machines made in two sizes Model 30 with hood 5 ft 6 in sq., with hand barring gear for traversing, and model 49, with hood 7 ft sq. on 4-wheeled, 4/5 ton trailer

ALEX LAURIE & SONS, FALKIRK

"LAURIE" trailers of every description for road construction and municipal purposes in connection with street cleansing, 5 to 6 ton for road work and 7 to 8 cu yds for cleansing purposes

LEWIN ROAD SWEEPERS, LTD

This Company, a member of the Brockhouse Group, specializes in municipal equipment for street cleansing

Plate 1, Nos 3 and 6 illustrate the SPRINKLER SWEEPER COLLECTOR, which is an all-weather vehicle The closed steel body is constructed with a main watertight sweeping compartment having a wet capacity of 80 cu ft, dry 120 cu ft with hinged tail-board The top covers fold back practically vertical when sweeping up light materials giving the above maximum capacities A water tank is constructed on each side of the body, running its full length, with a combined capacity of 170 gallons for damping or sprinkling purposes A simple hand-operated end tipping gear giving a high degree angle of Tip is provided for discharging all the Body contents The Sweeping and Collecting apparatus is totally enclosed The Sprinklers are fitted in front of the brush, and can be either gravity or pressure fed from a rotary pump at the driver's discretion

The sweeping width is 7 ft, and sweeping speeds from 3 to 10 m p h

Plate 1, No 7 illustrates the LEWIN COMPRESSING REFUSE COLLECTOR The patent cylindrical container is constructed of mild steel and mounted upon rollers with cross-channels suitably fixed to the chassis frame and uniformly distributing the load, whilst the Container remains stationary during the loading or packing operation, until it is "full"

When "full" the load is discharged by rotating the Container, using the reverse gear operated from the driver's cab

A hinged cover with a non-rotating charging plate is fitted at the rear, which is opened hydraulically by hand, from a pump located behind the cab

Speedy loading is obtained because the impellor uniformly keeps the chute clear, by moving the refuse forward in the main entrance until it is fully "packed" with the engine "ticking over"

No tipping gear is used, the container always remaining horizontal upon the chassis

The cylindrical container is encased, the hollow top forming a large carrier for salvage or bulky articles, with suitable steps on both sides

MODERN ASPHALT PAVEMENTS, LTD, MAIDSTONE, KENT

Asphalt surfacing, laying by hot process the various types of B S S and also asphalt by cold process

SCIENTIFIC ROADS (NORTHERN), LTD, SHIPLEY, YORKS

Tarred and bituminous roadstone, "FERRIPHIL" bituminous asphalt (hot), and "FERRIPHIL" carpet coating material (cold asphalt) for road construction, repairs and maintenance

SEALOCRETE PRODUCTS, LTD, LONDON, W 6

SEALOCRETE DEGREASING CRYSTALS, dissoluble in hot water, are used for removing grease and oil from concrete road surfaces

WM SMITH & SONS, BARNARD CASTLE

Road Sweeping Machines, horse or trailer type Snow-ploughs, "V" or single-blade type, for attaching to front of motor wagons

Roadmen's living huts, trailer types, with wood, iron or pneumatic-tyred wheels

Water and hand carts, horse or trailer type

W B STUBBS & SON, HAWKSWORTH, NOTTS

Various types of hand carts, hand trucks, and street orderly trucks for street cleansing, etc

THE TILLEY LAMP CO, LONDON, N W 10

Paraffin lamps, giving powerful light for excavations, emergency night work, etc These lamps are adjustable to suit any angle required

GEO TYRIE & SONS, LTD, LONDON, E C 2

A wide range of scavenger brooms, machine brooms, and road tar brushes, for street cleansing and road repair work

THE VIALIT CO, LTD

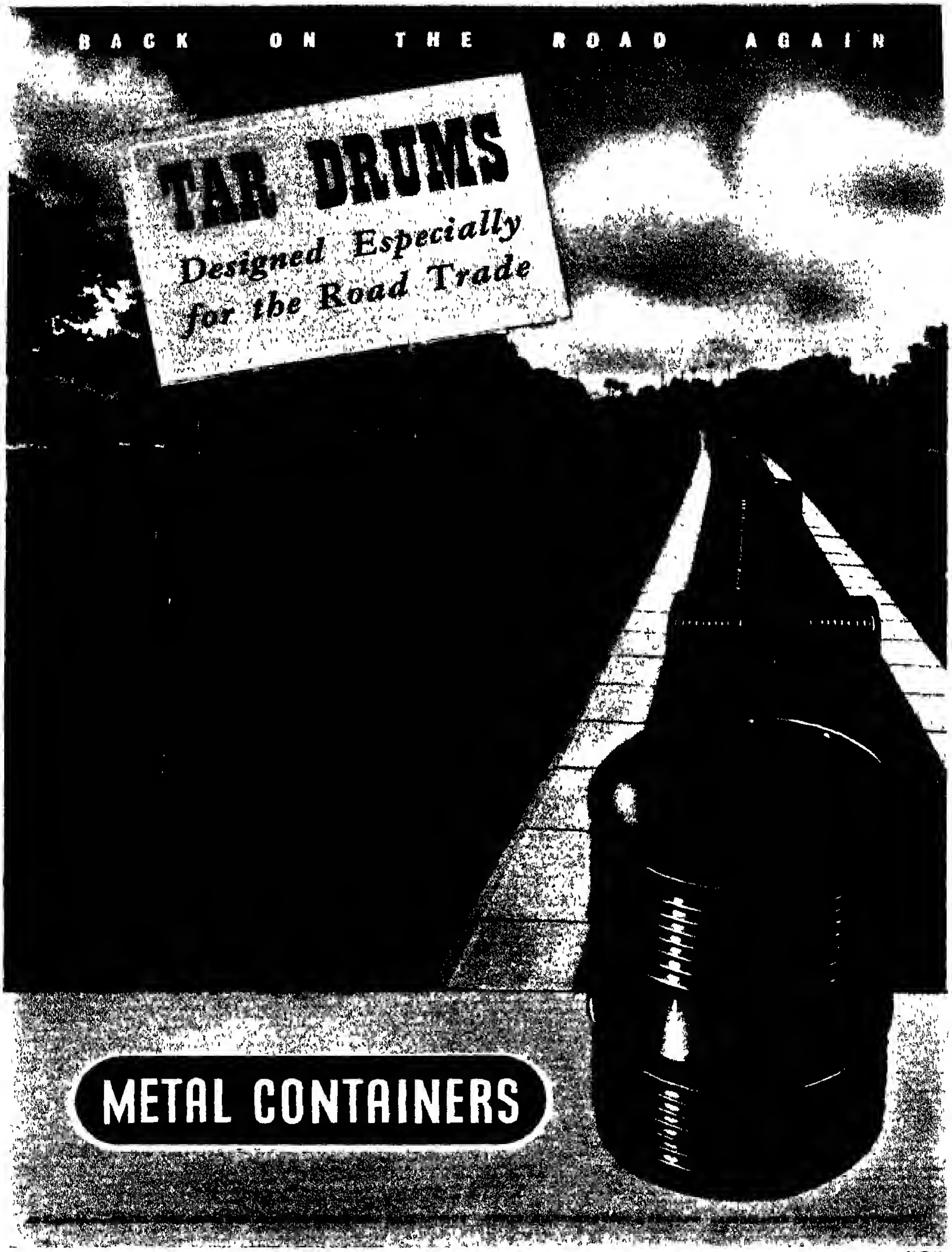
Grade A, cold bitumen emulsion containing 12 % bitumen content for grouting, semi-grouting and surface dressing Grade B, containing 55% bitumen content for surface dressing and curing concrete Tac Coat Grade, containing 30% bitumen content for veneer carpets and cold asphalt and "VIASOL" for inexpensive footpaths mixed in place

WHITLEY MORAN & CO, LTD, LIVERPOOL

GUNITE for the repair of bridges and viaducts, etc CEMENTATION for consolidation and strengthening of foundations, and for jacking up sunken road slabs and pavements

Whilst every care has been taken in compiling this information, the omission of any name must not be held as implying any deficiencies in the product of the company concerned

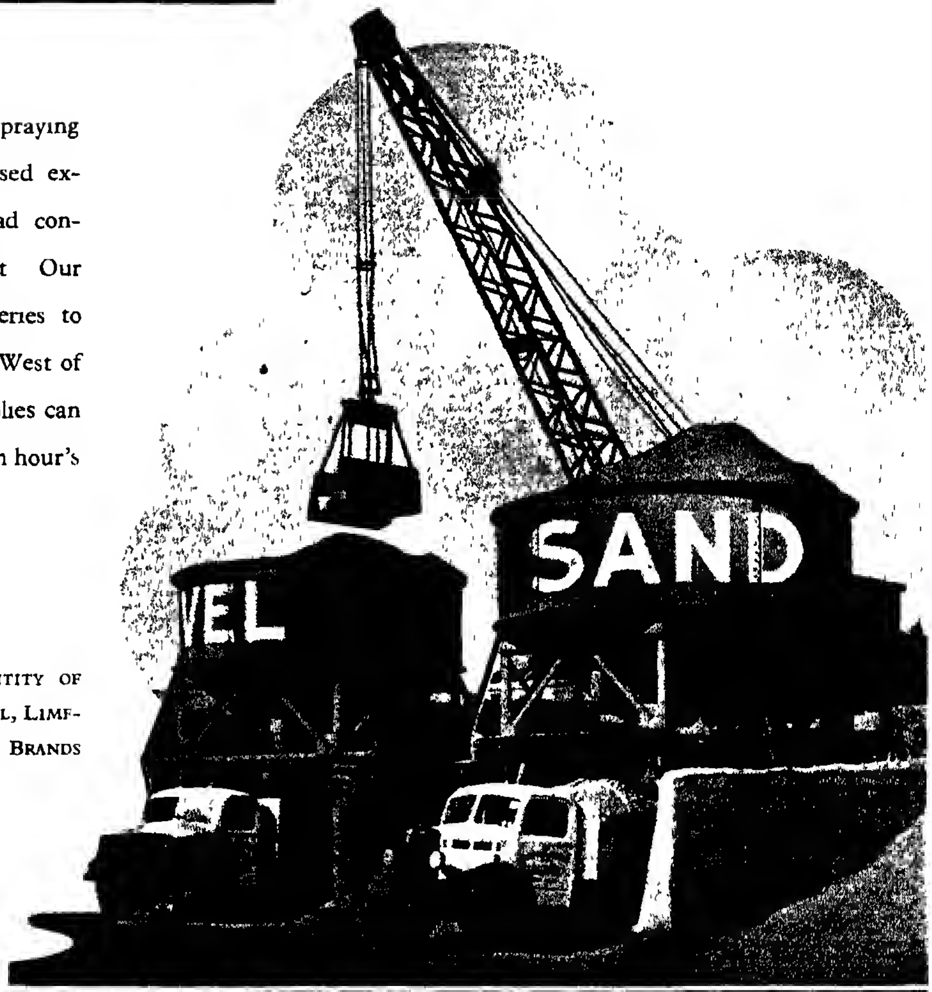
For full addresses see Manufacturer's Directory


BACK ON THE ROAD AGAIN
TAR DRUMS
Designed Especially for the Road Trade
METAL CONTAINERS

CHANNEL GRIT

for

Road Surfacing



The perfect grit for tar spraying and all concrete work Used extensively on important road contracts in the South West Our lorries make regular deliveries to all parts of Bristol and the West of England. Emergency supplies can be delivered from stock at an hour's notice.

WE CAN SUPPLY ANY QUANTITY OF HOLMS SAND, CHANNEL GRAVEL, LIMESTONE, AND ALL THE LEADING BRANDS OF CEMENT

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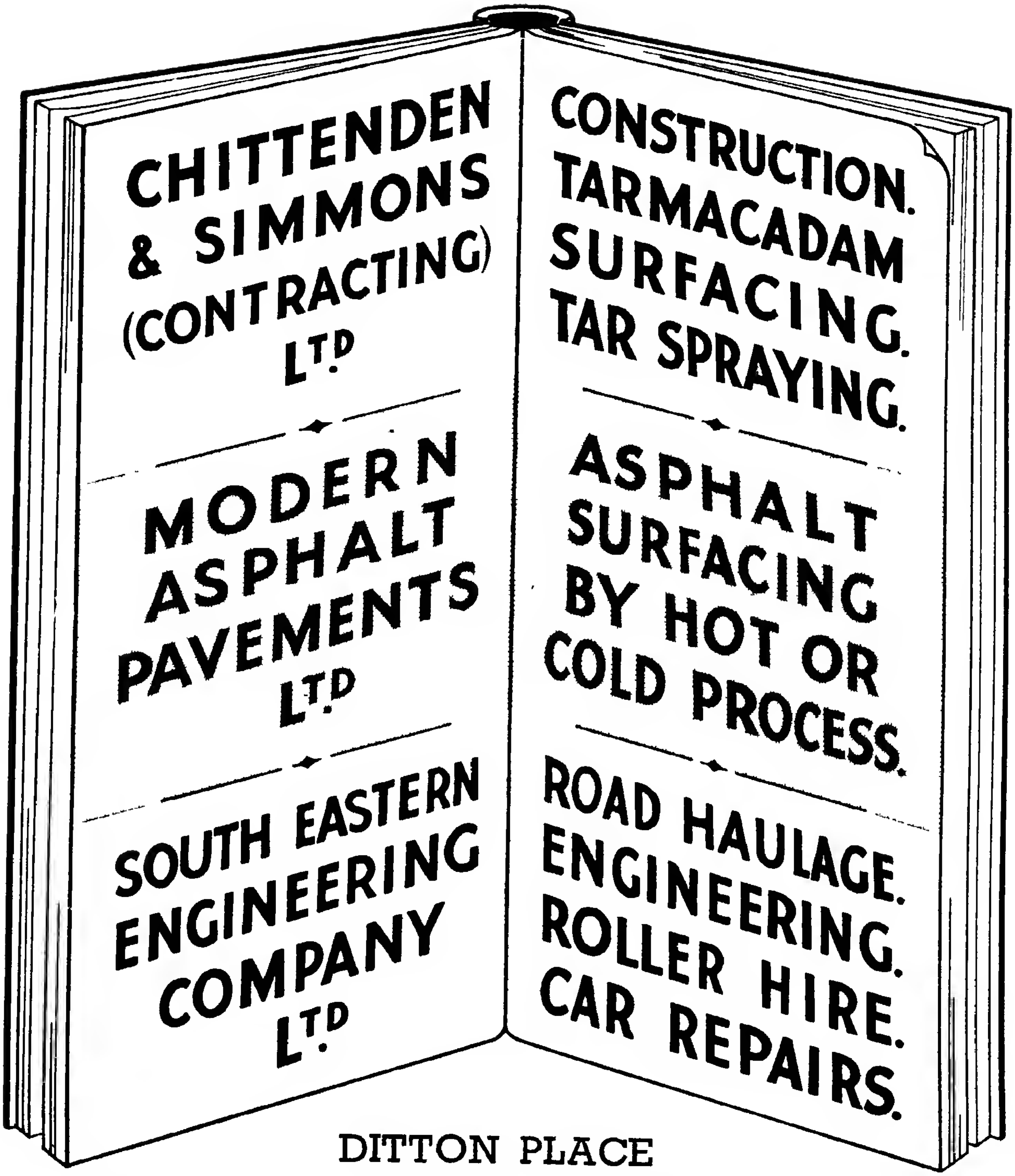

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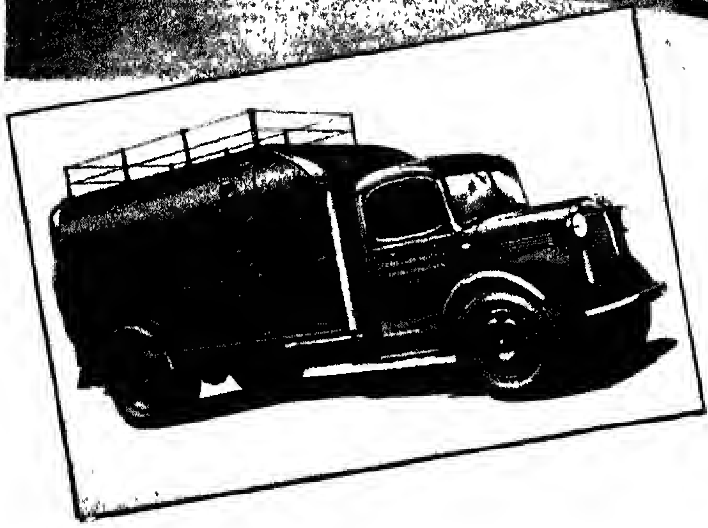

MODERN MUNICIPAL EQUIPMENT

The Lewin Road Sweeper and the Lewin Compressing Refuse Collector

These vehicles are outstanding examples of modern municipal equipment and they are unequalled for efficient and hygienic service.
They embody many exclusive patented features and reach a high degree of efficiency in their own particular sphere. Many Local Authorities, appreciating their advantages, now specify Lewin Vehicles for their Public Health Services. Send for particulars and specifications to:

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Holdens

'The Crossing Sweeper'' after a painting by W P Frith, 1819-1909 ★

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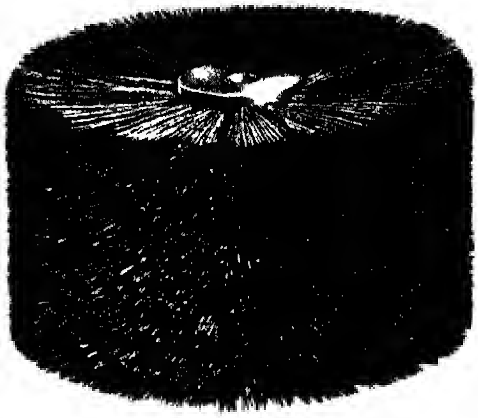

THE title of this advertisement aptly describes our manufacturing activities We have been road broom specialists for many generations and have always kept abreast of the times

Here depicted is a bass road broom which has always been accepted as the best of the hand-operated type There is also shown a sectional mechanical broom used in road cleaning machinery

These two types sold under the brand name of ARCHER'S TARGET BRUSHES fulfil their requirements in all directions

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APPENDIX

A LIST OF JOURNALS USEFUL FOR HIGHWAY ENGINEERS

BRITISH

"BULLETIN OF THE INSTITUTION OF HIGHWAY ENGINEERS"

55, Romney Street, Westminster, S.W 1

Published quarterly, free to Members of the Institution, containing general Institution news, papers and discussions relevant to Highway Engineering The charge for issues to non-members is 1s 6d

The Institution also publish an Annual Year-Book and List of Members Price to non-members, 2s per copy

"CIVIL ENGINEERING AND PUBLIC WORKS REVIEW"

Aldwych House, Aldwych, London, W C 2

Published monthly about the 15th of each month, covering the whole field of civil engineering, including articles on both theoretical subjects and current works Annual subscription post free, 15s , single copies 1s 3d or 1s 6d post free.

"ENGINEERING"

35 & 36, Bedford Street, Strand, London, W.C 2

Issued weekly on Friday, price 1s Publishes articles dealing with technical and scientific matters written by authorities on the subjects

"THE HIGHWAY ENGINEER AND LOCAL GOVERNMENT SURVEYOR"

8, Tharnton Park, Dalton-in-Furness, Lancashire

Published monthly, annual subscription, 21s including postage Edited and published honorarily by a group of surveyors and supplied only to Highway Engineers and Local Government Surveyors

"HIGHWAYS, BRIDGES AND AERODROMES"

A weekly publication specializing in the subjects indicated by its title It includes technical articles describing construction, materials, machinery and plant, and is an advocate of an improved road system providing economic transport and safety for all road users

"JOURNAL OF THE INSTITUTION OF MUNICIPAL AND COUNTY ENGINEERS"

Published monthly, price 3s , annual subscription £2 2s Consists of Papers presented at meetings of the Institution, contributed technical articles, book reviews etc , and includes a news section With each issue there is a loose inset of "*Road Abstracts*" (see below).

"THE KING'S HIGHWAY"

53, Victoria Street, Westminster, S.W 1

House journal of the Asphalt Roads Association, Ltd. Published twice yearly in January and July Price 1s. per copy Its object is to bring to the notice of the public matters of general interest regarding the history and development of roads

"MUCK SHIFTER AND PUBLIC WORKS DIGEST"

17, Stratford Place, London, W 1

A monthly journal published on the 16th of the month Subscription, 3 years 30s , one year, 15s. This journal covers the handling and transport of industrial and constructional materials and is primarily concerned with all public works operations in which the shifting of earth is involved Consideration is given to new planning schemes, future highway developments and all matters relating to large scale public works An important feature is the digest of articles dealing with civil engineering and public works taken from Colonial and Foreign periodicals

"MUNICIPAL ENGINEERING"

8, Bream's Buildings, London, E C 4

Published weekly, price 4d Annual subscription including a copy of the annual "Concise Municipal Directory", 24s 6d Deals extensively with highway construction, public works, etc , including all aspects of engineering, and reports of the proceedings of the Institution of Municipal & County Engineers, Institution of Highway Engineers, County Surveyors' Associations, etc The "Concise Municipal Directory" is a complete guide to the local authorities of Great Britain

"PASSENGER TRANSPORT JOURNAL"

Avenue Chambers, Vernon Place, Southampton Row, W C 1

Published monthly on the 2nd Friday of each month Subscription 25s per annum, including a copy of "Annual Year Book and Diary " This publication is of interest to highway engineers who are responsible for the maintenance of roads carrying tram-cars, trolley-buses and motor-buses

"THE REINFORCED CONCRETE REVIEW"

94–98, Petty France, Westminster, S W 1

Journal of the Reinforced Concrete Association, issued quarterly, price 1s 6d , free to members Reports new Codes of Practice, Standard Specifications, rules and regulations and official publications relating to all aspects of reinforced concrete, including highways, with a survey of world literature on the subject

"ROAD ABSTRACTS"

Compiled by the Department of Scientific and Industrial Research, Road Research Laboratory, Harmondsworth, Middlesex (Telephone Colnbrook 116), and the Ministry of Transport

This publication summarizes the world's literature on Roads It is issued monthly in neo-styled form to the technical press and is printed in full by the Institution of Municipal & County Engineers in co-operation with the Institution of Civil Engineers "Road Abstracts" appears as a monthly supplement (1s., annual subscription, 15s) to the Journal of the Institution of Municipal & County Engineers

"THE SURVEYOR AND MUNICIPAL AND COUNTY ENGINEER"

Goschen Buildings, 12–13, Henrietta Street, London, W C 2

Established over 50 years Published weekly on Friday Price 6d , annual subscription (post free) 28s United Kingdom, 32s abroad Deals exhaustively with all phases of highway engineering

"TRANSPORT WORLD"

82, Tankerville Road, London, S.W 16.

Published weekly and monthly (2nd Thursday), subscription rate, 25s per annum, 12s per annum for the monthly edition only. Contains information concerning public road transport, both passenger and goods, and information on the latest developments in highway construction as affecting the public service vehicle and road haulage operator

LIST OF JOURNALS USEFUL FOR HIGHWAY ENGINEERS

AMERICAN

"HIGHWAY RESEARCH ABSTRACTS"

Highway Research Board, National Research Council, 2101, Constitution Avenue, WASHINGTON, D C

"THE HIGHWAY MAGAZINE"

Published by Armco Drainage & Metal Products, Inc , MIDDLETOWN, OHIO

"DEPENDABLE HIGHWAYS"

National Paving Brick Association, National Press Buildings, WASHINGTON, D C
(Quarterly)

"QUARTERLY DIGEST OF 'CURRENT ASPHALT LITERATURE' "

The Asphalt Institute, 801, Second Avenue, NEW YORK, 17, N Y

"CALCIUM CHLORIDE ASSOCIATION NEWS"

Penobscot Buildings, DETROIT, 26, MICH

"AMERICAN HIGHWAYS"

Published by American Association of State Highways Officials, 1220, National Press Buildings, WASHINGTON, 4, D C

"PUBLIC ROADS"

A Journal of Highway Research, Issued by Federal Works Agency, Public Roads Administration, Federal Works Building, WASHINGTON, 25, D C

"ROADS & STREETS"

330, South Wells Street, CHICAGO, 6, ILLINOIS

"EXCAVATING ENGINEER"

SOUTH MILWAUKEE, WISCONSIN

"CIVIL ENGINEERING"

American Society of Civil Engineers, 20th and Northampton Streets, EASTON, PA

"CONCRETE"

Concrete Publishing Corp , 400, West Madison Street, CHICAGO, 6, ILLINOIS

"CRUSHED STONE JOURNAL"

1735, 14th Street, N W , WASHINGTON, 9, D C

AUSTRALIAN

"MAIN ROADS"

Dept of Main Roads, 309, Castlereagh Street, SYDNEY, N.S W.

"THE COMMONWEALTH ENGINEER"

MELBOURNE

FRENCH

"REVUE GENERALE DES ROUTES ET DE LA CIRCULATION ROUTIERE"

197, Boulevard Saint Germain, PARIS, VII

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